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NATIONAL DAM INSPECTION PROGRAM. GARDNER CREEK DAM (NDS-PA-0057--ETC(U)
JUN 78 DACW31-78-C-0046

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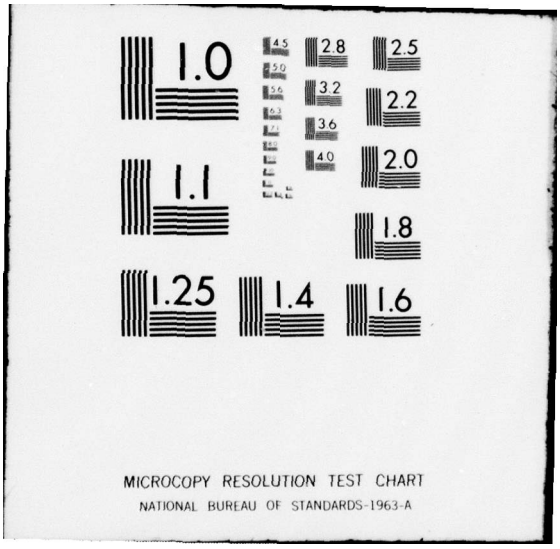
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SUSQUEHANNA RIVER BASIN
GARDNER CREEK, LUZERNE COUNTY

PENNSYLVANIA

(1)

LEVEL II

GARDNER CREEK DAM

NDS ID NO. PA-00575
DER ID NO. 40-1

PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

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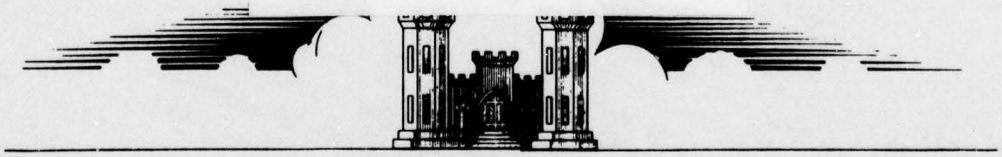

Prepared by
GANNETT FLEMING CORDDRY AND CARPENTER, INC.
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Harrisburg, Pennsylvania 17105

For
DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

JUNE 1978

SUSQUEHANNA RIVER BASIN

GARDNER CREEK, LUZERNE COUNTY

PENNSYLVANIA

(6) National Dam Inspection Program, Gardner Creek Dam (NDS-ID-PA-00575), (DER-ID-40-1), Pennsylvania Gas and Water Company. Susquehanna River Basin, Gardner Creek, Luzerne County, Pennsylvania. Phase I Inspection Report.

(12) 94 p.

GARDNER CREEK DAM

NDS ID No. PA-00575
DER ID No. 40-1

PENNSYLVANIA GAS AND WATER COMPANY

(15) DACW31-78-C-0046

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

Prepared by

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For

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Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

(11) JUNE 1978

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SUSQUEHANNA RIVER BASIN

GARDNER CREEK, LUZERNE COUNTY

PENNSYLVANIA

GARDNER CREEK DAM

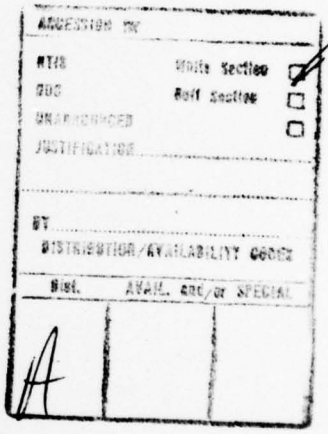
NDS ID No. PA-00575
DER ID No. 40-1

PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JUNE 1978



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NATIONAL DAM INSPECTION PROGRAM

BRIEF ASSESSMENT OF GENERAL CONDITION

AND

RECOMMENDED ACTION

Name of Dam:	Gardner Creek Dam (NDS ID No. PA-00575; DER ID No. 40-1)
Owner:	Pennsylvania Gas and Water Company
State Located:	Pennsylvania
County Located:	Luzerne
Stream:	Gardner Creek
Date of Inspection:	22 May 1978
Inspection Team:	Gannett Fleming Corddry and Carpenter, Inc. Consulting Engineers P.O. Box 1963 Harrisburg, Pennsylvania 17105

Based on the visual inspection, available records, calculations and past operational performance, Gardner Creek Dam is judged to be in fair condition. However, the spillway will not pass the Probable Maximum Flood (PMF) or one-half of the PMF without overtopping. If Gardner Creek Dam should fail due to overtopping, the hazard to loss of life downstream from the dam would be significantly increased from that which would exist just prior to overtopping. Based on criteria established for these studies by the Department of the Army, Office of the Chief of Engineers (OCE), the spillway capacity is rated as seriously

inadequate. The existing spillway can accommodate a flood with a peak inflow of 20 percent of the PMF peak flow. If the low area of the top of embankment were brought up to grade, the spillway would accommodate a flood with a peak inflow of 31 percent of the PMF peak inflow.

In view of the concern for safety of Gardner Creek Dam, the following measures are recommended to be undertaken by the Owner immediately:

(1) Develop a detailed emergency operation and warning system for Gardner Creek Dam.

(2) Perform additional studies to more accurately ascertain the spillway capacity required for Gardner Creek Dam and the nature and extent of remedial measures required to make the spillway and spillway walls hydraulically and structurally adequate. Filling in the existing low area of the top of embankment would help increase the spillway capacity, and this should be accomplished before other remedial measures are implemented.

(3) Monitor differential movement of left spillway wall at regular intervals.

In order to correct operational, maintenance and repair deficiencies, and to more accurately determine the condition of the dam, the following measures are recommended to be undertaken by the Owner in a timely manner:

(1) Remove brush growing on upstream slope of embankment and in spillway approach area.

(2) Replace missing riprap near spillway.

(3) Repair bare path on downstream slope of embankment.

(4) Fill hole on downstream slope of embankment caused by burrowing animal.

(5) Install four or more observation wells, or other instrumentation, in the downstream slope of the embankment. Two wells should be installed at intervals along the 20-inch pipes through the embankment to monitor any possible leakage along the pipes. The others should be located at the Owner's discretion. Monitor instruments and record data so that any change in condition is detected.

(6) Install valves or otherwise develop a means of rapidly closing off the 20-inch lines through the embankment from their upstream ends.

(7) Either eliminate the flow from the right hillside or provide positive conveyance facilities for the flow to safe areas well away from the dam.

(8) Lubricate gears on operating equipment in gatehouse. Maintain and operate gates on a regular basis.

(9) Develop an alternate access route to the dam that would be accessible under all conditions.

The following measures are recommended to be undertaken by the Owner when the need arises:

(1) Provide round-the-clock surveillance of Gardner Creek Dam during periods of unusually heavy rains.

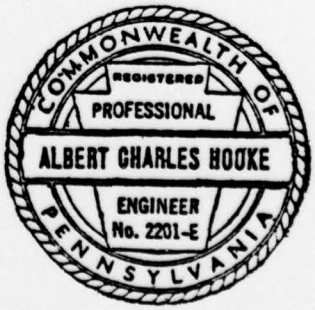
(2) When warnings of a storm of major proportions are given by the National Weather Service, the Owner should activate his emergency operation and warning system procedures.

Submitted by:

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.

A. C. HOOKE
Head, Dam Section

Date: 19 July 1978



Approved by:

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS

G. K. WITHERS
Colonel, Corps of Engineers
District Engineer

Date: 30 Jul 78

GARDNER CREEK DAM

Embankment, Spillway, and Gatehouse
Looking Upstream

SUSQUEHANNA RIVER BASIN

GARNDER CREEK, LUZERNE COUNTY

PENNSYLVANIA

GARDNER CREEK DAM

NDS ID No. PA-00575
DER ID No. 40-1

PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JUNE 1978

ABSTRACT

SECTION 1

PROJECT INFORMATION

1.1 General.

a. Authority. The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

b. Purpose. The purpose of the inspection is to determine if the dam constitutes a hazard to human life or property.

ABSTRACT

1.2 Description of Project.

a. Dam and Appurtenances. Gardner Creek Dam is an earthfill embankment with a central masonry core wall. The embankment is 470 feet long and is 43 feet high. The

upstream slope is riprapped and the downstream slope has a grass cover. The spillway is located at the left abutment. It is a concrete gravity structure, 70 feet long and 38 feet high, with a stepped downstream face. Embankment fill is against the upstream face of the spillway. Concrete walls on each side of the spillway act as retaining walls and as training walls for discharge over the spillway. The outlet works is located near the center of the embankment and consists of two 20-inch diameter cast-iron pipes through the embankment. Downstream from the dam, the 20-inch pipes are cross connected to feed a single 30-inch diameter water supply line. There is a 16-inch diameter blowoff line on the cross connection of the 20-inch lines. Various features of the dam are shown on the Plates at the end of the report and on the Photographs in Appendix D.

b. Location. The dam is located on Gardner Creek about 4.5 miles upstream of the confluence with Mill Creek. Gardner Creek Dam is shown on USGS Quadrangle, Pittston, Pennsylvania, with coordinates N41°16'15" - W75°45'55" in Luzerne County and is 4 miles east of Wilkes-Barre, Pennsylvania. The location map is shown on Plate 1.

c. Size Classification. Intermediate (43 feet high, 300 acre-feet).

d. Hazard Classification. High hazard. Downstream conditions indicate that a high hazard classification is warranted for Gardner Creek Dam (Paragraph 5.1e.).

e. Ownership. Pennsylvania Gas and Water Company, Wilkes-Barre, Pennsylvania.

f. Purpose of Dam. Water supply for the Borough of Laflin, Plains Township, Jenkins Township, and the City of Wilkes-Barre, Pennsylvania.

g. Design and Construction History. Gardner Creek Dam was built by the Spring Brook Water Supply Company between 1898 and 1902. The dam was designed and constructed under the supervision of John Lance, Chief Engineer of the Spring Brook Water Supply Company.

As originally constructed, the difference in elevation between the spillway crest and the top of dam was 2 feet. Studies of the dam performed in 1914 and 1917 by the Pennsylvania Water Supply Commission resulted in recommendations to repair deteriorated concrete of the spillway and spillway walls and to raise the embankment by 3 feet in order to increase the spillway capacity. The work was completed in 1930.

Modifications were made to the water distribution system in 1941. The modifications did not include any work upstream for the gatehouse, which is located at the toe of the dam.

h. Normal Operational Procedure. The reservoir is normally maintained at spillway crest level. Water for distribution is drawn from the two 20-inch lines through the dam, which feed a 30-inch supply line. The valve on the blowoff line is normally closed. Reservoir inflow is augmented by a 6-mgd capacity, 30-inch diameter line from Watres Reservoir that enters Gardner Creek 0.5 mile upstream from Gardner Creek Dam. Flow from this line is regulated by a valve near its outlet.

1.3 Pertinent Data.

a. Drainage Area. 3.7 square miles.

b. Discharge at Damsite. (cfs.)

Maximum known flood at damsite - unknown.
Emergency drawdown line at maximum pool elevation - 74 (approximate).
Spillway capacity with pool at Elevation 1079.2 - 1,640.

c. Elevation. (Feet above msl.)

Top of dam (design) - 1080.6.
Top of dam (low spot) - 1079.2.
Maximum pool - 1079.2.
Normal pool (spillway crest) - 1075.4.
Upstream intake invert outlet works - 1032.0.
Downstream invert outlet works - 1031.0.
Streambed at centerline of dam - 1040.0. (approximate).

d. Reservoir Length. (Miles.)

Normal pool - 0.35.
Maximum pool - 0.36.

e. Storage. (Acre-feet.)

Normal pool (spillway crest) - 222.
Maximum pool (design top of dam) - 300.

f. Reservoir Surface. (Acres.)

Normal pool (spillway crest) - 15.
Maximum pool (design top of dam) - 15.8.

g. Dam.

Type - Earthfill embankment with central masonry core wall.

Length - Embankment only - 470 feet.
Embankment and spillway - 540 feet.

Height - 43 feet.

Top Width - 8 feet.

Side Slopes - Downstream - 1V on 1.75H above El. 1064.4 - 1V on 2H below El. 1064.4.
Upstream - 1V on 2H.

Zoning - None - central masonry core wall.

Cutoff - Central masonry core wall from 4 feet to 16 feet below original ground surface.

Grout Curtain - None.

h. Diversion and Regulating Tunnels. None.

i. Spillway.

Type - Broad-crested weir (width 4.0 feet) with stepped downstream face.

Length of Weir - 70 feet.

Crest Elevation - 1075.4.

Upstream Channel - 1V on 4.5H rock-lined embankment slope.

Downstream Channel - Stone-lined channel.

j. Regulating Outlets.

Type - Two 20-inch diameter cast-iron pipes (CIP) through embankment. Pipes feed 30-inch diameter water supply line. 16-inch CIP blowoff line from supply cross connection.

Length - 165 feet.

Access - None.

Regulating Facilities - Two manually operated nonrising stem 20-inch gate valves with exposed 3 to 1 gear reducers for each 20-inch CIP in gatehouse at toe of dam. Additional gate valves downstream in valve pits for distribution. One 16-inch in-ground nonrising stem gate valve for 16-inch blowoff on supply cross connection.

SECTION 2

ENGINEERING DATA

2.1 Design.

a. Data Available. Engineering data for the original structures that was available for review was limited to a short report on the design and construction that was written by John Lance, chief engineer for the dam. The report was published in "Transactions of the Association of Civil Engineers of Cornell University, 1901". The report information includes a general description of the project, results of tests for crushing strength of stone used in the masonry core wall, a description of the quarrying and borrow operations, the mortar and concrete mix proportions used in the work, and a description of the construction of the outlet works.

In 1914, a report on Gardner Creek Dam was prepared by the Pennsylvania Water Supply Commission. Additional information covered in that report includes a description of project features and foundation conditions, and hydraulic and stability analyses for the spillway. The 1914 report, and a supplementary report prepared in 1917, were the bases for the increase in spillway capacity that was accomplished in 1930.

b. Design Features. The primary features of Gardner Creek Dam include an earthen embankment with a masonry core wall, a concrete gravity spillway, and an outlet works. A general plan is shown on Plate 2 and a profile along the axis of the dam is shown on Plate 3.

The embankment is an earthfill structure with a central masonry core wall. The embankment is 470 feet long and is 43 feet high. The embankment section is shown on Plate 4. As originally constructed, the embankment had a top width of 10 feet and side slopes of 1V on 2H. In 1930, for the purpose of increasing spillway capacity, the embankment was raised 2 feet. The increase in height was accomplished by raising the crest vertically on the upstream side, reducing the top width to 8 feet, and steepening a

portion of the downstream surface from the origianl 1V on 2H to 1V on 1.75H. The top of the masonry core wall is 3 feet lower than the top of the dam. The core wall is 3 feet wide at the top and at intervals it is stepped outward so that its bottom width is 6 feet. Available information indicates that the base of the core wall is located to depths of up to 16 feet below original ground surface. The core wall is founded upon an 18-inch thick concrete footing that rests on hardpan. The embankment was constructed upon a firm clay. A discussion on geology is presented in Appendix E. The embankment fill consists of a sandy clay with a high percentage of gravel. The embankment materials were borrowed from nearby areas. The upstream slope of the embankment is protected by hand-placed riprap to within 1 foot of the top of the dam. The downstream slope of the embankment is covered with a mixture of weeds and very small shrubs.

The spillway is located at the left abutment and is a concrete gravity structure. The spillway section is shown on Plate 4. The top width of the spillway is 4 feet, the upstream face is vertical except for one offset 0.7 foot wide, and the downstream face is stepped downward at a slope of 1V on 0.58H. The spillway crest is 70 feet long and is at Elevation 1075.4. Embankment fill is against the upstream face of the spillway, and the fill is covered with riprap. The spillway is founded on hardpan. A cutoff wall, 4 feet thick, connects the left side of the spillway with the left abutment. The right spillway wall is a concrete gravity structure that begins at the downstream face of the spillway and extends downstream for about 85 feet. The wall retains the adjacent embankment fill and acts as a training wall for spillway discharge. The left spillway wall also acts as a training wall and extends downstream about 112 feet, and it retains the natural abutment slope. The spillway walls are shown on Plates 5 and 7. The discharge channel is about 65 feet wide at the base of the spillway. Immediately downstream from the spillway, the discharge channel bends to the right and the spillway walls converge so that at the ends of the spillway walls, the discharge channel is about 37 feet wide. A concrete apron lines the channel from the toe of the spillway to the ends of the spillway walls.

The outlet works consists of two 20-inch diameter cast-iron pipes through the embankment, a gatehouse at the toe of the dam, a 30-inch diameter water supply line, and a 16-inch diameter blowoff line that can be used to lower the water level in the reservoir. According to available information, the 20-inch lines through the embankment, for their full length, are founded on a 2-foot thick masonry bed that rests on a 1-foot thick concrete footing. One-foot thick masonry arches were constructed around the 20-inch lines. In the gatehouse, two gate valves are on each line. Beyond the gatehouse, the two 20-inch lines are cross connected to feed water into a 30-inch supply line. A 16-inch blowoff line is joined to the cross connection. One 16-inch gate valve is located underground to control the blowoff line. A plan of the outlet works is shown on Plate 6.

2.2 Construction.

a. Data Available. Construction data available for review included both the report by John Lance, chief engineer for the project, and the 1914 report by the Pennsylvania Water Supply Commission, which had some information obtained by interviews with David John foreman during construction. Plans are available for the modifications made in 1930.

b. Construction Considerations. The Lance report indicates that the stone used for the core wall was a conglomerate having an average compressive strength of about 17,000 psi. Embankment fill upstream from the core wall was borrowed from within the reservoir area. Some of the downstream fill was screenings and gravel from the processing operation for obtaining sand for mortar and concrete. Available records did not indicate the source of the remaining material in the downstream fill. The report also described the installation of the two 20-inch pipes through the core wall. An annular space was left around each pipe and, several weeks after construction of the core wall, the annular space was grouted.

The 1914 report by the Pennsylvania Water Supply Commission indicates that the topsoil was stripped before placement of embankment fill. It also reports that the entire upstream fill was hand tamped. No topsoil was spread on the downstream slope of the embankment.

In general, the accounts of the construction, though limited, are such that it appears that some care was used for construction of Gardner Creek Dam. However, no mention was made of cleaning the stone for the core wall or for moisture control during placement of embankment fill. Performance of the concrete in the structures, as discussed in Section 3, has been such that it indicates that it was of rather poor quality.

2.3 Operation. Few formal records of operation are available. The dam has been inspected at irregular intervals by Commonwealth authorities since 1914 and, in recent years, annual inspections have been made by the Owner. The available records indicate that the problems that were observed in this inspection have existed for many years.

2.4 Other Investigations. In 1950, the Owner, which was then the Scranton-Spring Brook Water Service Company, the extent of deterioration of the spillway and the spillway walls. In 1953, preliminary design studies were made by Thomas H. Wiggin, Consulting Engineer, for the Owner for the purpose of repairing deteriorated structures and increasing spillway capacity. These studies did not result in repairs or improvements.

2.5 Evaluation.

a. Availability. Engineering data was provided by the Division of Dams and Encroachments, Bureau of Water Quality Management, Department of Environmental Resources, Commonwealth of Pennsylvania, and by the Owner, Pennsylvania Gas and Water Company. The Owner made available an engineer, a caretaker, and a valve crew for information and operating demonstrations during the visual inspection. The Owner also researched his files for additional information upon request of the inspection team.

b. Adequacy. The type and amount of design data and other engineering data are limited, and the assessment must be based on the combination of available data, visual inspection, performance history, hydrologic assumptions, and hydraulic assumptions.

c. Validity. There is no reason to question the validity of the available data.

SECTION 3

VISUAL INSPECTION

3.1 Findings.

a. General. The general appearance of this project indicated that some project features have deteriorated with age and are in need of repair, while other project features have been properly maintained and are in good condition.

b. Dam.

(1) The top of the embankment had some vertical irregularities. A survey of the top of embankment indicated that the average elevation was about Elevation 1080.6. However, a low area was present over about a 10-foot length at the right side of the spillway (Elevation 1079.2) and a high area was found near the right abutment (Elevation 1081.3).

(2) The upstream slope of the embankment was adequately maintained except that some light brush was growing near the water level (Photograph A). Riprap was intact and continuous except for a 30-foot reach adjacent to the right side of the spillway (Photograph H).

(3) The downstream slope of the embankment had a uniform slope and was adequately maintained. (Photographs A and B). The vegetation consisted of a light growth of weeds and very small shrubs. The type and extent of the vegetation indicated a rather fragile environment. There appeared to be very little topsoil available to support development of sod. Vegetation on the downstream slope had been cut recently. A path was worn or excavated on the downstream slope near the right abutment to a maximum depth of 2 feet. One hole caused by a burrowing animal was located near the center of the dam about 10 feet above the toe. Signs of recent burrowing were observed.

(4) A wet area was located at the toe of the embankment at the gatehouse. Clear, standing water about 2 inches deep was present, but no actual flow was visible. No adverse effects on other features appear to have resulted from the wet area.

(5) Considerable clear flow was observed coming from the right abutment area. Although the actual source was not determined, the flow was traced to an area on the hillside well above the dam. The water is collected by an access road and it flows down into the valley downstream from the dam. No damage or adverse effects have resulted from this flow. The caretaker said that he believed the source of water might be a leaking pipeline located on the hillside.

c. Appurtenant Structures.

(1) A small amount of light brush was growing in the spillway approach area (Photograph B). Riprap on the slope of the embankment fill that is against the upstream face of the spillway is intact and continuous.

(2) Flow over the spillway crest and over the stepped downstream face of the spillway was not uniform due to disintegration of the concrete (Photographs C and D). Coarse aggregate was exposed over most of the area, and the disintegration had progressed to an estimated depth of 6 inches at some locations. The steps on the downstream face were badly eroded and, in some cases, missing. The downstream face of spillway could not be inspected for leakage or cracking because of the amount of water flowing over it.

(3) A concrete apron, shown on the drawings to extend from the tow of the spillway to the end of the spillway walls, was not visible. It was assumed that the accumulation of soil, rock, and other debris in the outlet channel were covering the concrete apron (Photographs D, E, and F). It was noted that there was no apparent undermining at the toe of the spillway.

(4) The right spillway wall had very severe scaling over about 30 percent of its exposed face (Photograph D). The average depth of scaling was about 1 inch. A vertical crack was located near the downstream end of the wall. The crack is weathered, but no differential movement was observed.

(5) The left spillway wall had severe disintegration over about 80 percent of its exposed face (Photographs E and F). The worst area was a about mid-height near the toe of the spillway (Photograph E). At that location, the estimated depth of disintegration was 2 feet. An average depth of disintegration for the wall could not be determined. A 70-foot long crack, predominantly horizontal and located about 4 feet above the channel bottom, begins near the downstream end of the wall and entends upstream into the area of most severe disintegration (Photographs E and F). The portion of the wall above the crack was overhanging the lower portion by an average of 0.35 foot.

(6) The valves in the gatehouse at the toe of the dam were buried in the ground and covered with straw to prevent freezing during the winter. The valves were open because the water was being drawn for distribution. There are no valves at the upstream end of the 20-inch intake lines. The exposed spur and pinion gears were rusty. The 16-inch diameter valve on the blowoff was opened about 30 turns during this inspection (Photograph G). Prior to opening the valve, the blowoff outlet was buried in mud. The caretaker said that the valve had not been opened for about 15 years. The valve operated easily, but it was not opened fully because the Owner was concerned about drawing turbid water into the supply line. The Owner said that the valve would have to be opened in small increments over a reasonable period of time to avoid drawing turbid water into the supply line. After opening the valve, the outlet of the blowoff was clear. It was noted that there was a small spring at the bottom of the outlet channel for the blowoff line about 10 feet beyond the end of the blowoff line. The source of the spring could not be determined.

d. Reservoir Area. The slopes adjacent to the reservoir are covered with hardwoods. No evidence was noted of creep, rock slides, or land slides. The Owner indicated that sedimentation is not a problem from the standpoint of reduced reservoir capacity. The watershed is completely owned by Pennsylvania Gas and Water Company and is undeveloped.

e. Downstream Channel. According to available information, the bottom of the channel immediately downstream from the spillway is concrete. However, at the time of the

inspection the concrete could not be seen as it was covered with soil, gravel, and some debris. The channel converges from a width of 65 feet at the spillway to a width of 37 feet at the natural channel. In this reach where the channel converges, the channel has concrete walls at its sides and it has approximately a 40-degree turn to the right. The natural channel is straight and uniform and runs into a wooded area about 200 feet downstream from the spillway. There is a horseshoe conduit through the 35-foot high Pennsylvania Turnpike embankment about 2,000 feet downstream from the dam. The access route to the dam includes driving through this conduit. At the downstream end of the Pennsylvania Turnpike conduit, a 60-foot long open channel leads to a second horseshoe conduit through a 25-foot high Lehigh Valley Railroad embankment.

3.2 Evaluation.

a. Dam.

(1) The small variations in the elevation of the top of embankment are of little concern. However, the 10-foot long reach near the spillway is about 1.4 feet lower than the average top of dam elevation, and it is considered to be an excessive variation. Overflow would occur at this location before the maximum pool elevation would be reached, and substantial erosion of the embankment in the vicinity of the spillway might result.

(2) The light brush growing on the upstream slope of the embankment is undesirable. The 30-foot reach adjacent to the spillway where the riprap is missing could easily be eroded during large flood flows or by wave action.

(3) Although the vegetation on the downstream slope of the embankment appeared to be fragile, it is sufficient to prevent erosion and gullying from normal runoff of rainfall as long as it is undisturbed. However, the path near the right abutment was bare, and the exposed soil appeared to be erodible. If not repaired, erosion at the path will continue. The hole on the downstream slope of the embankment caused by a burrowing animal is undesirable. If seepage should occur through the adjacent embankment material, the hole could collect the seepage and result in a flow concentration through erodible material.

(4) The wet area at the toe of the embankment near the gatehouse has been reported on previous inspections at least as far back as 1920. The nature of the wet area, which appears to be stable and nondamaging, and its history indicate that the wet area is not a serious problem at the present time. However, it should be recognized that it is located near the area where two pipes come through the embankment, and that neither pipe has valves on the upstream end. The pipes are, therefore, under pressure through the embankment.

(5) The flow from the right hillside originates from a source well above the dam, and, consequently, is only of interest insofar as the effects of the flow on the dam. Previous inspection reports indicate that the flow developed at least as early as 1933. The flow is collected by an access road at the right end of the dam and is routed some distance downstream before it crosses the road and enters the valley below the dam. Apparently no adverse effects have resulted. However, because there is no positive provision for routing the flow, such as a ditch, it is possible that in the future the flow might enter the area below the dam in an undesirable location.

b. Appurtenant Structures.

(1) The light brush in the spillway approach area is undesirable. However, it is not of sufficient size to impose any operating constraints on the spillway.

(2) The overall condition of the spillway and the spillway walls are generally unsatisfactory. Review of previous inspection reports indicates that deterioration of the concrete began at least as early as 1919. Repairs were made to the exposed faces of the spillway walls in 1930, but the present condition of the walls is poor. The deterioration of the concrete on the spillway and the right wall does not appear to be so extensive as to seriously endanger the structures at present. However, the left spillway wall has deteriorated to the extent that its structural integrity is questionable. A study of the condition of the spillway was made by the Scranton-Spring Brook Water Service Company in 1950. At that time, the horizontal crack and differential movement had already occurred. Drawings from the files of

the Owner indicate an average movement at that time of 0.16 foot. The present average displacement is 0.35 foot. This increase in displacement, coupled with areas of disintegration to depths of about 2 feet, indicates a potentially serious condition. If this wall failed, a slide of the adjacent hillside would probably also occur. It could not be determined from the visual inspection whether a failure of the wall would seriously endanger the dam and the spillway. The effects of failure would depend on extent of failure, amount of sliding of the hillside, and pool level at time of failure. It is sufficient to say that every effort should be made to avoid a failure of the wall.

(3) The overall condition of the operating equipment was adequate. There are no valves on the upstream end of the two 20-inch lines through the embankment, and the lines are always under pressure. Therefore, if leakage occurred along the lines, there would be no way to close the lines except by having a diver plug them. Leakage could result in piping of embankment materials. The potential hazard of the condition is offset to some extent because the lines are completely surrounded by masonry construction as described in Paragraph 2.1b..

c. Reservoir Area. No conditions were observed in the reservoir area that might present significant hazard to the dam.

d. Downstream Channel. No conditions were observed in the downstream channel that might directly present of the inspection water was flowing about 6 inches deep in the conduit. Access to the dam during periods of high spillway discharge or during the winter might not be possible. Possible effects of the Pennsylvania Turnpike conduit and the Lehigh Valley Railroad conduit with respect to failure of the dam are discussed in Paragraph 5.1e.

SECTION 4

OPERATIONAL PROCEDURES

4.1 Procedure. The reservoir is maintained at spillway crest level with excess inflow cascading over the stepped concrete spillway. Two 20-inch diameter cast-iron pipes draw water from the reservoir at Elevation 1040.0 to gravity feed distribution lines in the communities of Laflin, Plains Township, Jenkins Township, and Wilkes-Barre. Normal runoff does not meet demand requirements and the reservoir inflow is augmented by a 6 mgd capacity, 30-inch diameter, supply line from Watres Reservoir that enters Gardner Creek 0.5 miles upstream from the dam. The supply line flow is normally throttled to 4 mgd by a 30-inch gate valve located in a valve pit near the end of the pipe on the left bank of Gardner Creek. Two 20-inch diameter gate valves for each 20-inch line are located in the gatehouse at the toe of the dam. These valves are all normally open. Valve pits located about 80 feet downstream from the toe of the dam have additional gate valves that cross-connect the flow from both 20-inch lines into a single 30-inch diameter transmission line. A 16-inch diameter blowoff line comes off the cross-connection of the two 20-inch lines. The blowoff line can be used to remove sediment or to lower the pool level in the reservoir. A 16-inch diameter cast-iron gate valve that is on the blowoff line is located underground and is normally closed. The Owner said that the valve had not been operated for about 15 years.

4.2 Maintenance of Dam. The dam is visited daily by a caretaker who checks chlorination equipment and records the reservoir elevation. He reports the water level each day to the Owner's Engineering Department by telephone, and he makes a written weekly report. This information is used by the Engineering Department for regulating flows within the supply and distribution system. The caretaker for Gardner Creek Dam has been on the job for 36 years. The caretaker is also responsible for observing the general condition of the dam and appurtenant structures and for reporting any changes or deficiencies to the Owner's Engineering Department. A Pennsylvania Gas and Water Company engineer makes a

formal inspection of the dam each year, and the records are kept on file and used for determining priority of repairs. Informal inspections are also made when the engineer is on the site for other reasons. The brush on the embankment is cut annually.

4.3 Maintenance of Operating Facilities. There is no known regular maintenance program for the operating facilities. Maintenance is apparently performed at intervals as deemed necessary.

4.4 Warning Systems in Effect. The Owner furnished the inspection team with a chain of command diagram for Gardner Creek Dam and a generalized emergency notification list that is applicable for all Pennsylvania Gas and Water Company dams. The Owner said that during periods of heavy rainfall, available personnel are dispatched to the dams to observe conditions. All company vehicles are equipped with radios and the personnel can communicate with each other and with a central control facility located in Wilkes-Barre. However, the caretaker uses a privately owned vehicle that is not equipped with a radio. Evaluation of risk is made by the Owner's Engineering Department. The Owner's Engineering Department is also responsible for notification of emergency conditions to the local authorities. Detailed emergency operational procedures have not been formally established for Gardner Creek Dam, but are as directed by the Owner's Engineering Department.

4.5 Evaluation. Except for not opening the blowoff valve on a regular basis, the operational procedure appears to be satisfactory. Infrequent operation of the blowoff could affect its functioning satisfactorily during emergency conditions. The procedures used by the Owner for inspecting the dam are adequate, but repairs have not been made. In general, the warning system is adequate, but it should be more detailed.

SECTION 5

HYDROLOGY AND HYDRAULICS

5.1 Evaluation of Features.

a. Design Data.

(1) No hydrologic and hydraulic analyses for the original Gardner Creek Dam design were reviewed. The spillway capacity was estimated before and after the dam was raised in 1930.

(2) In the recommended guidelines for safety inspection of dams, the Department of the Army, Office of the Chief of Engineers (OCE), established criteria for rating the capacity of spillways. The recommended spillway design flood for the size (intermediate) and hazard potential (high) classification of Gardner Creek Dam is the Probable Maximum Flood (PMF). If the dam and spillway are not capable of passing the PMF without overtopping failure, the spillway capacity is rated as inadequate. If the dam and spillway are capable of passing one-half of the PMF without overtopping failure, the spillway capacity is not rated as seriously inadequate. A spillway capacity is rated as seriously inadequate if all of the following conditions exist:

(a) There is a high hazard to loss of life from large flows downstream of the dam.

(b) Dam failure resulting from overtopping would significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure.

(c) The dam and spillway are not capable of passing one-half of the PMF without overtopping failure.

(3) The Gardner Creek watershed is owned by the Pennsylvania Gas and Water Company and is undeveloped. Hydrologic analysis for this study was based on existing conditions and the effects of future development of the watershed were not considered.

b. Experience Data. For this study, a PMF peak previously calculated for a potential reservoir site on Fall Brook was transposed to the Gardner Creek watershed. The PMF peak flow was estimated to be 8,870 cfs at Gardner Creek Dam. In 1953, Thomas H. Wiggin, consulting engineer, calculated the spillway capacity at 2,620 cfs for the maximum head on the spillway of 5.2 feet. Calculations were performed for this study to check the accuracy of the Wiggin report, and the spillway capacity of 2,620 cfs was accepted as the spillway capacity with pool at design top of dam elevation (1080.6). As noted in Section 3, the top of embankment has a low area at the spillway. The top of embankment at this low area is Elevation 1079.2. The spillway capacity with pool at Elevation 1079.2 is 1,640 cfs, and this was used in this study as the existing spillway capacity. Hydraulic computations are included in Appendix C.

c. Visual Observations. On the date of the inspection, no conditions were observed that would indicate that the spillway capacity would be significantly reduced during a flood occurrence.

d. Overtopping Potential. For an occurrence of the PMF, the peak inflow of 8,870 cfs is greater than the spillway capacity of Gardner Creek Dam. A check of the surcharge storage effect of Gardner Creek Reservoir shows that the surcharge storage available is insufficient to contain the PMF inflow hydrograph without overtopping the dam (Appendix C).

e. Downstream Conditions. As shown on Plate 1, Gardner Creek Dam is located on Gardner Creek upstream from the communities of Wilkes-Barre, Laflin, and Westminster. The first populated area downstream is at Westminster, which is about 0.8 mile downstream from the dam. Some of these houses are adjacent to Gardner Creek. About midway between the dam and the first populated area, the embankments of the Northeast Extension of the Pennsylvania Turnpike and the Lehigh Valley Railroad cross the valley. The distance between the toes of the two embankments is about 60 feet. The Turnpike embankment is closest to the dam and is about 35 feet high and about 330 feet wide at its base. The

conduit through the embankment is a concrete horseshoe type with a width of 18.6 feet and a height of 13.0 feet (Photograph I). Just downstream from the Turnpike embankment is the railraod embankment. It is about 25 feet high and about 100 feet wide at the base. The material in the railroad embankment fill appeared to be cinders. The conduit through the railroad embankment is a masonry horseshoe type with a width of 9.8 feet and a height of 12 feet (Photgraph J). If Gardner Creek Dam failed, the two downstream embankments could decrease or increase the hazard to human life or property. If the embankments did not fail as a result of a failure of Gardner Creek Dam, the hazard to human life and property would decrease. If the embankments did fail as a result of a failure of Gardner Creek Dam, the hazard to human life and property could increase. The mechanics of the interaction between the failure of Gardner Creek Dam and the two downstream embankments are complex and beyond the scope of this study. Therefore, it cannot be assumed that the hazard to human life and property resulting from a failure of Gardner Creek Dam would be reduced by the existence of the two downstream embankments. Consequently, the downstream conditions indicate that a high hazard classification is warranted for Gardner Creek Dam.

f. Spillway Adequacy.

(1) The spillway will not pass the PMF without overtopping the dam. One-half of the PMF inflow is 4,435 cfs and is greater than the spillway capacity. A check of the surcharge storage effect of Gardner Creek Reservoir shows that the surcharge storage available is insufficient to contain an inflow with a peak flow of 4,435 cfs without overtopping the dam (Appendix C).

(2) The maximum tailwater is estimated to be Elevation 1044 at the spillway capacity of 1,640 cfs. At maximum pool elevation, there is a difference of about 35 feet between headwater and tailwater. If Gardner Creek should fail due to overtopping, the hazard to loss of life downstream from the dam will be significantly increased from that which would exist just prior to overtopping.

(3) Based on established OCE criteria as outlined in Paragraph 5.1a.(2), the spillway capacity of Gardner Creek Dam is rated as seriously inadequate. Considering the effects of the surcharge storage of 58 acre-feet, the spillway discharge capacity of 1,640 cfs can accommodate a flood with a peak inflow of 1,750 cfs for a storm of the same duration as the PMF. This is 20 percent of the PMF peak inflow.

(4) If the low area of the top of embankment were to be brought up to grade, which would be a relatively minor maintenance task, the spillway capacity would be increased to 2,620 cfs. This would permit the accommodation of a flood with a peak inflow of approximately 2,770 cfs or 31 percent of the Gardner Creek PMF peak flow. The spillway capacity of Gardner Creek Dam would still be rated as seriously inadequate.

SECTION 6

STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability.

a. Visual Observations.

(1) General. The visual inspection of Gardner Creek Dam resulted in a number of observations relevant to structural stability. These observations are listed herein for the various features.

(2) Embankment. A seepage area with standing water was observed at the toe of the embankment next to the gatehouse. The detailed description and evaluation of the condition are in Paragraph 3.1b.(4) and 3.2a.(4), respectively.

(3) Spillway. The concrete on the downstream face of the spillway is disintegrated. The concrete on the left spillway retaining wall is also disintegrated, and the wall is cracked. There has been some wall displacement of the left spillway wall above the crack. The detailed description and evaluation of these conditions are in Paragraphs 3.1c. and 3.2b.(2), respectively.

b. Design and Construction Data. No records of design data or stability computations for the original structures were available for review. However, a stability analysis for the spillway was made in 1914 by the Pennsylvania Water Supply Commission and the results of the analysis are on file.

The stability analysis performed by the Commission used the following maximum loading conditions: headwater at Elevation 1078.4 (3 feet over spillway crest), zero tailwater, and uplift varying from two-thirds full at the heel to zero at the toe. No load was considered for the embankment fill against the upstream face. The results of the analysis showed that the resultant was outside the middle third but within the base, about 5 feet from the toe, and that toe pressures were satisfactory. However, the computations for resistance to sliding did not show that the foundation could develop sufficient resistance. It was concluded that the structure was stable against sliding because it is a short structure that is incorporated with the walls at each end and because its foundation is 6 feet lower than the bottom of the spillway channel.

In view of the loading assumptions and results of the analysis by the Commission, a stability analysis was made for the spillway for this study. Only the bottom of the spillway section was considered. The loading assumptions used in this study are as follows: headwater at Elevation 1080.6 (maximum pool level), 4.4 feet of tailwater, upstream earth pressure considered as at rest pressure, uplift determined by the creep method, and passive resistance available downstream. Based on the above assumptions, the resultant was found to be outside the middle third but within the base, about 4 feet from the toe. It it is assumed that the hardpan foundation behaves as a very weak shale, the computed toe pressures and resistance to sliding indicate that the stability of the spillway is probably marginal. However, it should be recognized that the analysis was based on assumed soil and foundation properties.

c. Operating Records. There is no evidence that any stability problems have occurred for the dam or the spillway during the operational history of the dam. However, as discussed in Paragraphs 3.1c(5) and 3.2b.(2), the left spillway wall has cracked and is apparently undergoing a slow displacement.

d. Post-Construction Change. As noted herein, there is adequate information concerning the change made in 1930.

e. Seismic Stability. Gardner Creek Dam is located in Seismic Zone 1. Normally, it can be considered that if a dam in this zone is stable under static loading conditions, it can be assumed safe for any expected earthquake loading. However, since there is the potential of earthquake forces moving or cracking the masonry gravity section, the theoretical seismic stability of this dam cannot be assessed.

SECTION 7

ASSESSMENT, RECOMMENDATIONS, AND REMEDIAL MEASURES

7.1 Dam Assessment.

a. Safety.

(1) Based on the visual inspection, available records, calculations and past operational performance, Gardner Creek Dam is judged to be in fair condition. However, deficiencies of varying degree of importance were noted. A summary of the features and observed deficiencies is listed below:

Feature and Location	Observed Deficiencies
Embankment:	
Top of embarkment	Low area near spillway
Upstream slope	Light brush; loss of riprap near spillway.
Downstream slope	Bare path; hole by burrowing animal.
Downstream toe	Wet area at gatehouse.
Right hillside above dam	Seepage.
Spillway:	
Approach area	Light brush.
Crest and downstream face	Concrete disintegration.
Apron	Covered with soil and debris.
Right wall	Scaling and vertical crack.
Left wall	Severe disintegration; horizontal crack with differential movement.

Feature and Location	Observed Deficiencies
Outlet Works:	
20-inch pipes	No valves on upstream ends.
Valve gears	Rust.
Access Route to Dam:	Unreliable during high flows or during the winter.

(2) The overtopping potential analysis shows that Gardner Creek Dam will be overtopped by the PMF and by one-half the PMF. Based on OCE criteria, as outlined in Paragraph 5.1a.(2), the spillway capacity is rated seriously inadequate. The existing spillway can accommodate a flood with a peak inflow of 20 percent of the PMF peak inflow. If the low area of the top of embankment were brought up to grade, the spillway would accommodate a flood with a peak inflow of 31 percent of the PMF peak inflow.

(3) Review of the 1914 stability computations and computations made for the purpose of this study indicate that for the condition of maximum loading, the resultant is outside the middle third, but it is within the base, about 4 feet from the toe. However, based on the assumptions made for soil and foundation properties, the factors of safety for toe pressures and sliding resistance appear to be marginal. If the left spillway wall should continue to undergo displacement to the point of failure, some reserve resistance to sliding offered by the left spillway wall might be lost.

(4) The embankment for the Northeast Extension of the Pennsylvania Turnpike and the embankment for the Lehigh Valley Railroad cross the Gardner Creek Valley between the dam and the first populated area. Horseshoe conduits through the embankments carry the outflow from Gardner Creek Dam. Evaluation of the ability of these structures to withstand a flood wave resulting from a failure of Gardner Creek Dam and evaluation of the failure hydrograph modification that might result were beyond the scope of this study. Therefore, it cannot be assumed that the hazard to human life and property resulting from a failure of Gardner Creek Dam would be reduced by the existence of the two downstream embankments.

b. Adequacy of Information. The information available is such that an assessment of the condition of the dam can be inferred from the combination of visual inspection, past performance, and computations performed prior to and as part of this study.

c. Urgency. The recommendations in Paragraph 7.2 should be implemented immediately or in a timely manner, as noted.

d. Necessity for Further Investigations. In order to accomplish some of the remedial measures outlined in Paragraph 7.2, further investigations will be required.

7.2 Recommendations and Remedial Measures.

a. In view of the concern for safety of Gardner Creek Dam, the following measures are recommended to be undertaken by the Owner immediately:

(1) Develop a detailed emergency operation and warning system for Gardner Creek Dam.

(2) Perform additional studies to more accurately ascertain the spillway capacity required for Gardner Creek Dam and the nature and extent of remedial measures required to make the spillway and spillway walls hydraulically and structurally adequate. Filling in the existing low area of the top of embankment would help increase the spillway capacity, and this should be accomplished before other remedial measures are implemented.

(3) Monitor differential movement of left spillway wall at regular intervals.

b. In order to correct operational, amintenance and repair deficiencies, and to more accurately determine the condition of the dam, the following measures are recommended to be undertaken by the Owner in a timely manner:

(1) Remove brush growing on upstream slope of embankment and in spillway approach area.

(2) Replace missing riprap near spillway.

(3) Repair bare path on downstream slope of embankment.

(4) Fill hole on downstream slope of embankment caused by burrowing animal.

(5) Install four or more observation wells, or other instrumentation, in the downstream slope of the embankment. Two wells should be installed at intervals along the 20-inch pipes through the embankment to monitor any possible leakage along the pipes. The others should be located at the Owner's discretion. Monitor instruments and record data so that any change in condition is detected.

(6) Install valves or otherwise develop a means of rapidly closing off the 20-inch lines through the embankment from the upstream end.

(7) Either eliminate the flow from the right hillside or provide positive conveyance facilities for the flow to safe areas well away from the dam.

(8) Lubricate gears on operating equipment in gatehouse. Maintain and operate gates on a regular basis.

(9) Develop an alternate access route to the dam that would be accessible under all conditions.

c. The following measures are recommended to be undertaken by the Owner when the need arises:

(1) Provide round-the-clock surveillance of Gardner Creek Dam during periods of unusually heavy rains.

(2) When warnings of a storm of major proportions are given by the National Weather Service, the Owner should activate his emergency operation and warning system procedures.

SUSQUEHANNA RIVER BASIN

GARDNER CREEK, LUZERNE COUNTY

PENNSYLVANIA

GARDNER CREEK DAM

NDS ID No. PA-00575
DER ID No. 40-1

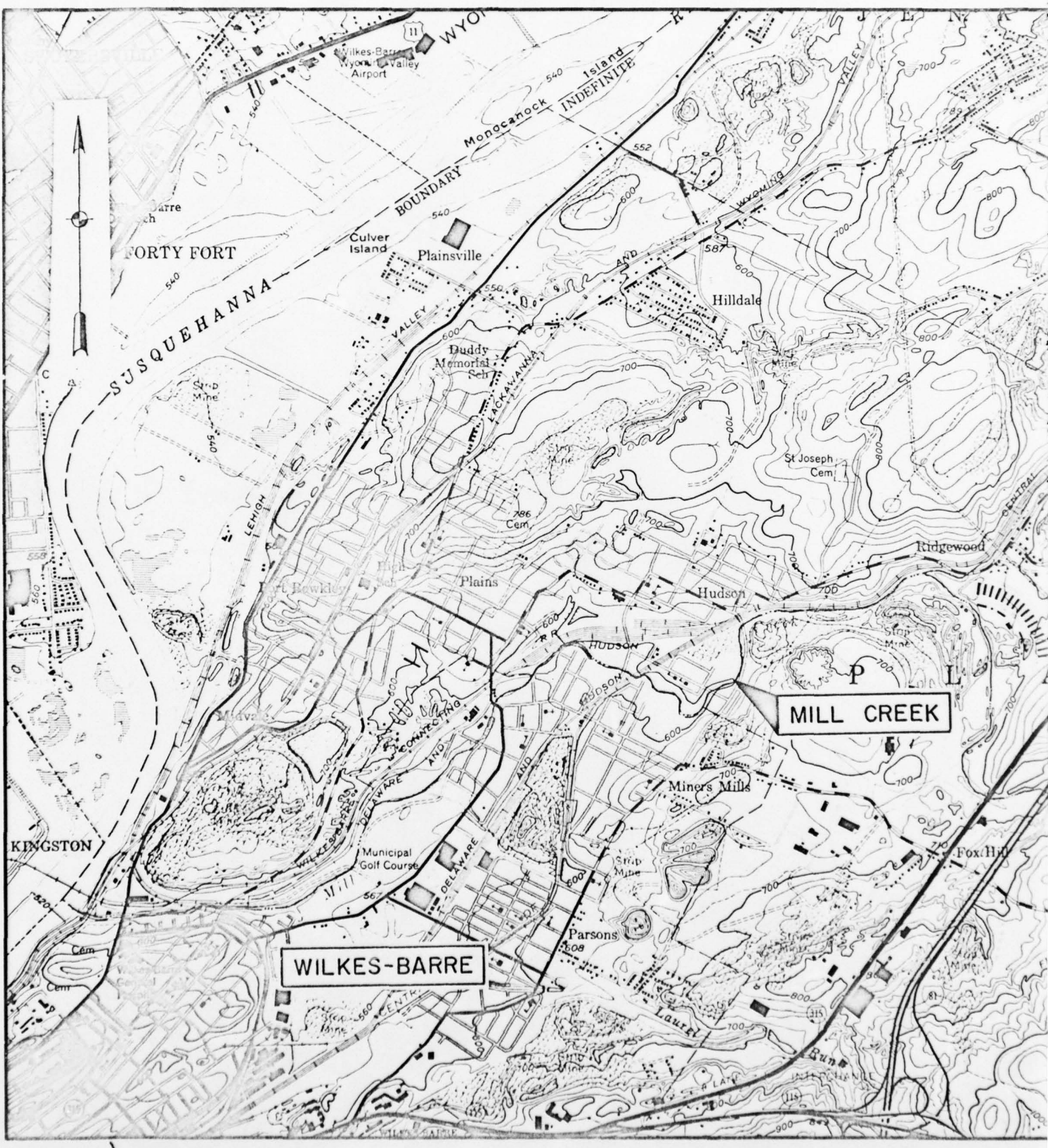
PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JUNE 1978

PLATES


Wilkes-Barre Wyoming Valley Airport
Monocanock Island
INDEFINITE BOUNDARY
SUSQUEHANNA
FORTY FORT
Culver Island
Plainsville
Duddy Memorial Sch
Hilldale
St Joseph Cem
Ridgewood
Plains
Hudson
MILL CREEK
Miners Mills
KINGSTON
Municipal Golf Course
Parsons
WILKES-BARRE
Fox Hill
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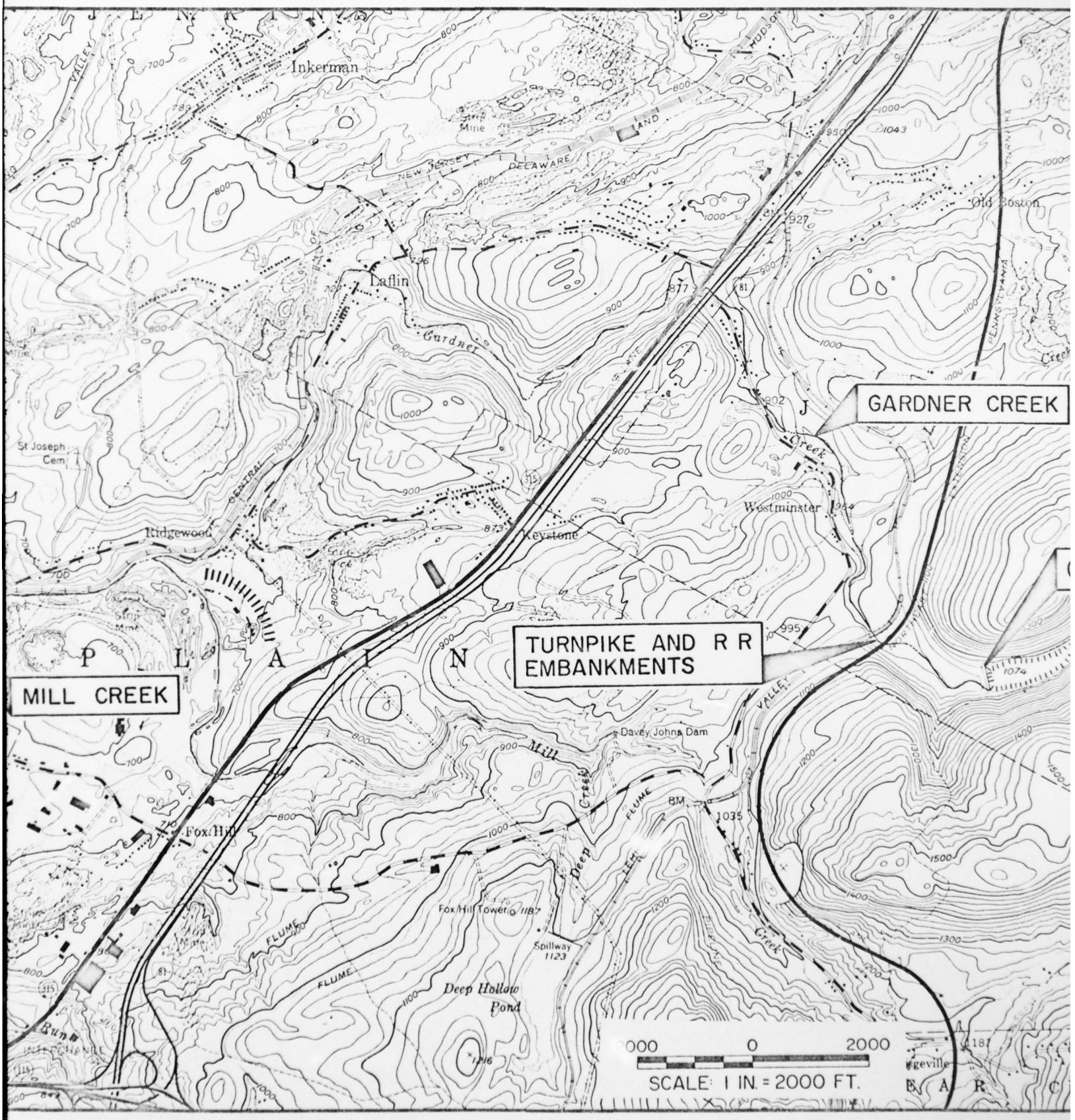
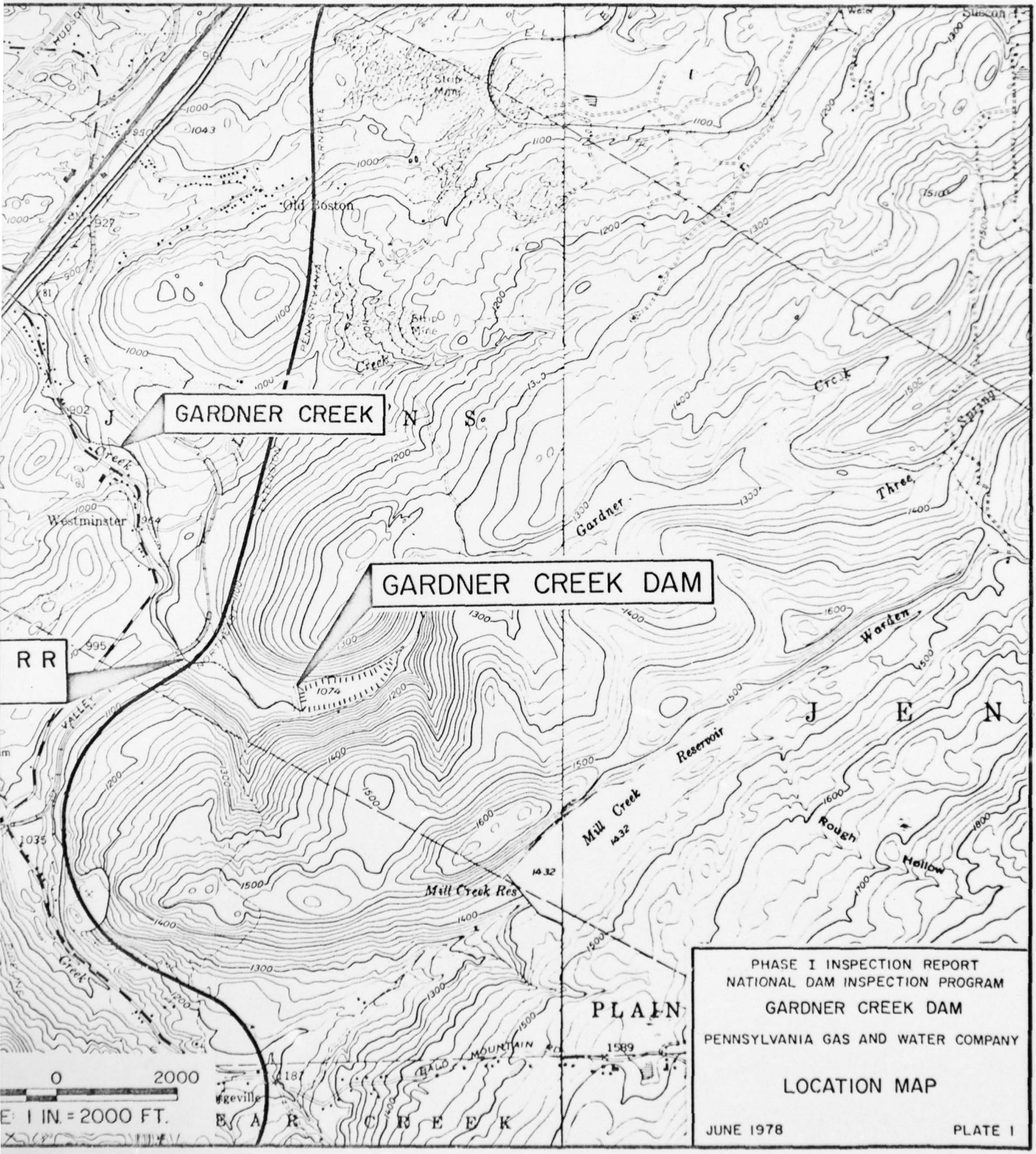
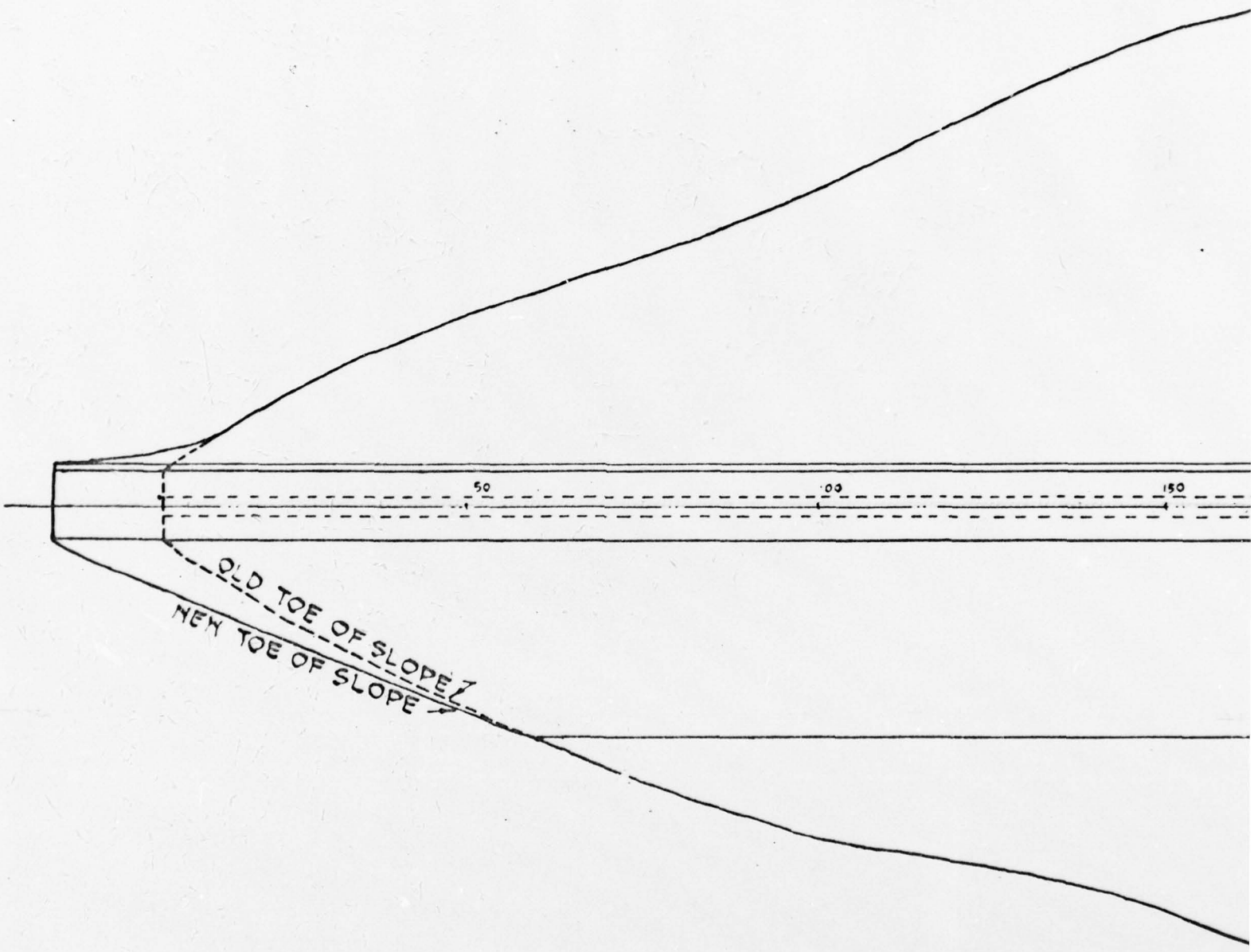
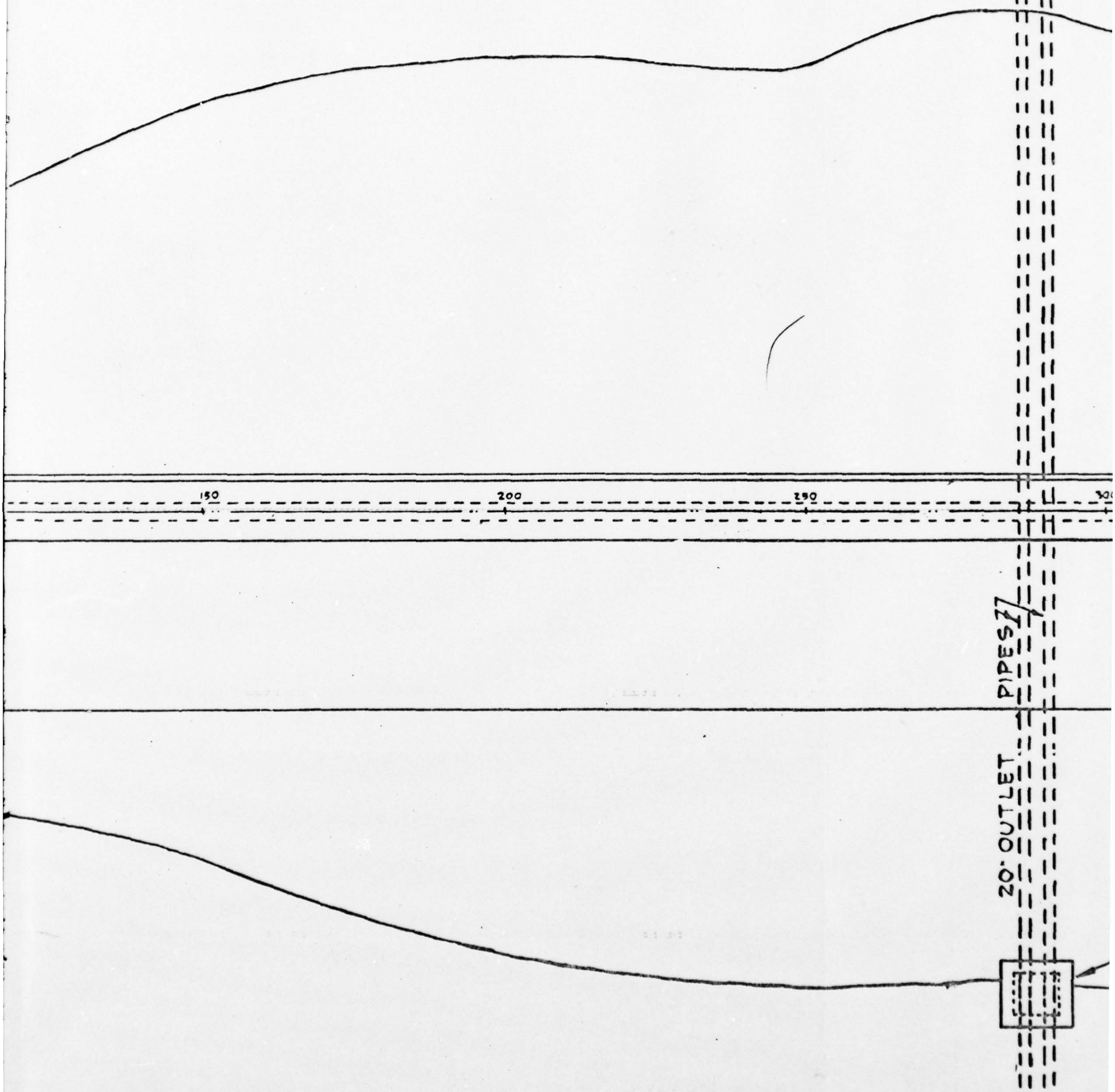
DELAWARE AND HUDSON
DELAWARE AND LACKAWANNA
CENTRAL RR OF NJ
WYOMING VALLEY
Strip Mine
Cem

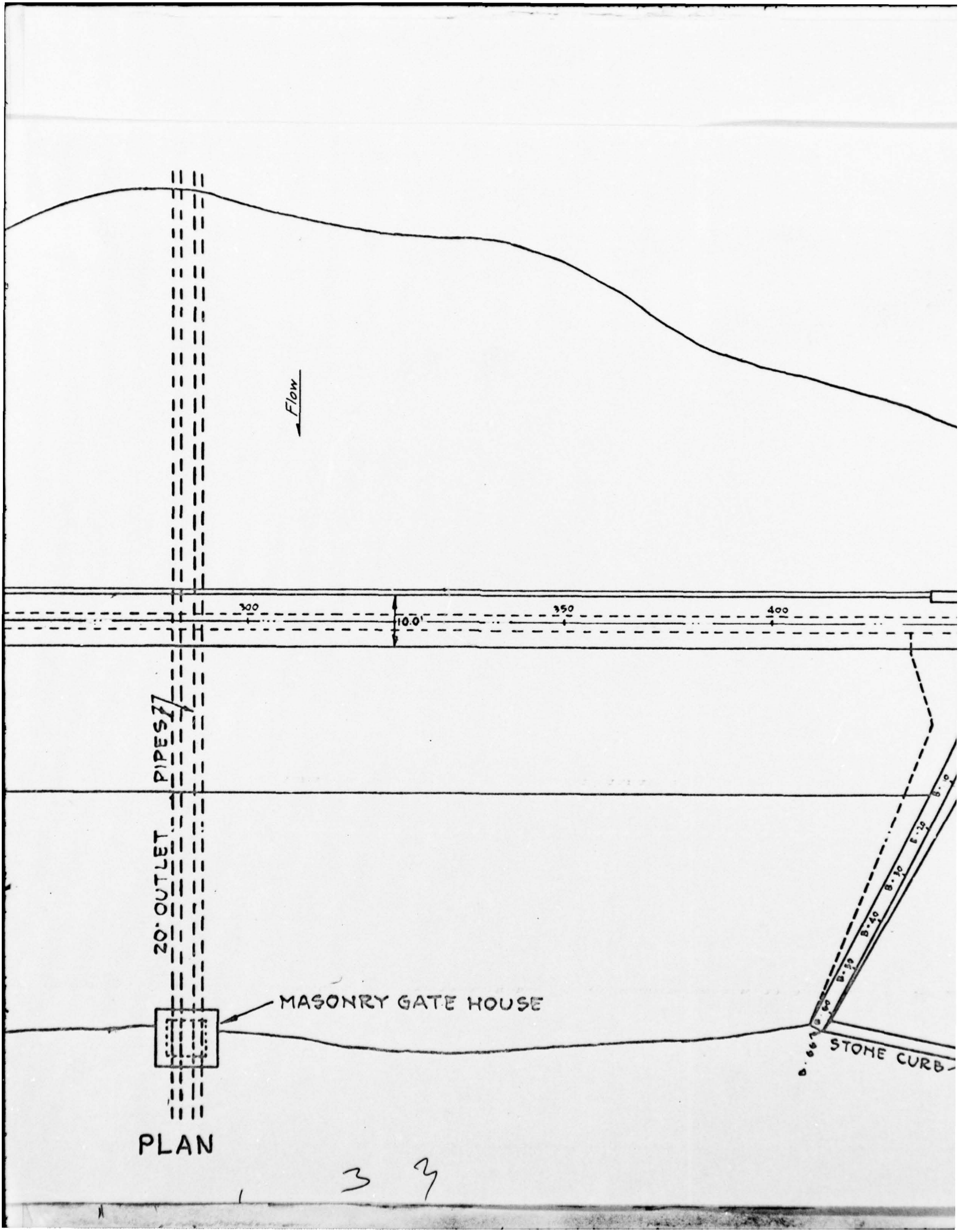

GARDNER CREEK
TURNPIKE AND R R EMBANKMENTS
MILL CREEK
Inkerman
Laflin
Gardner
Old Boston
Ridgewood
Keystone
Westminster
Fox Hill
Davey Johns Dam
Mill Creek
Deep Creek
Fox Hill Tower
Spillway 1123
Deep Hollow Pond
FLUME
SCALE: 1 IN. = 2000 FT.

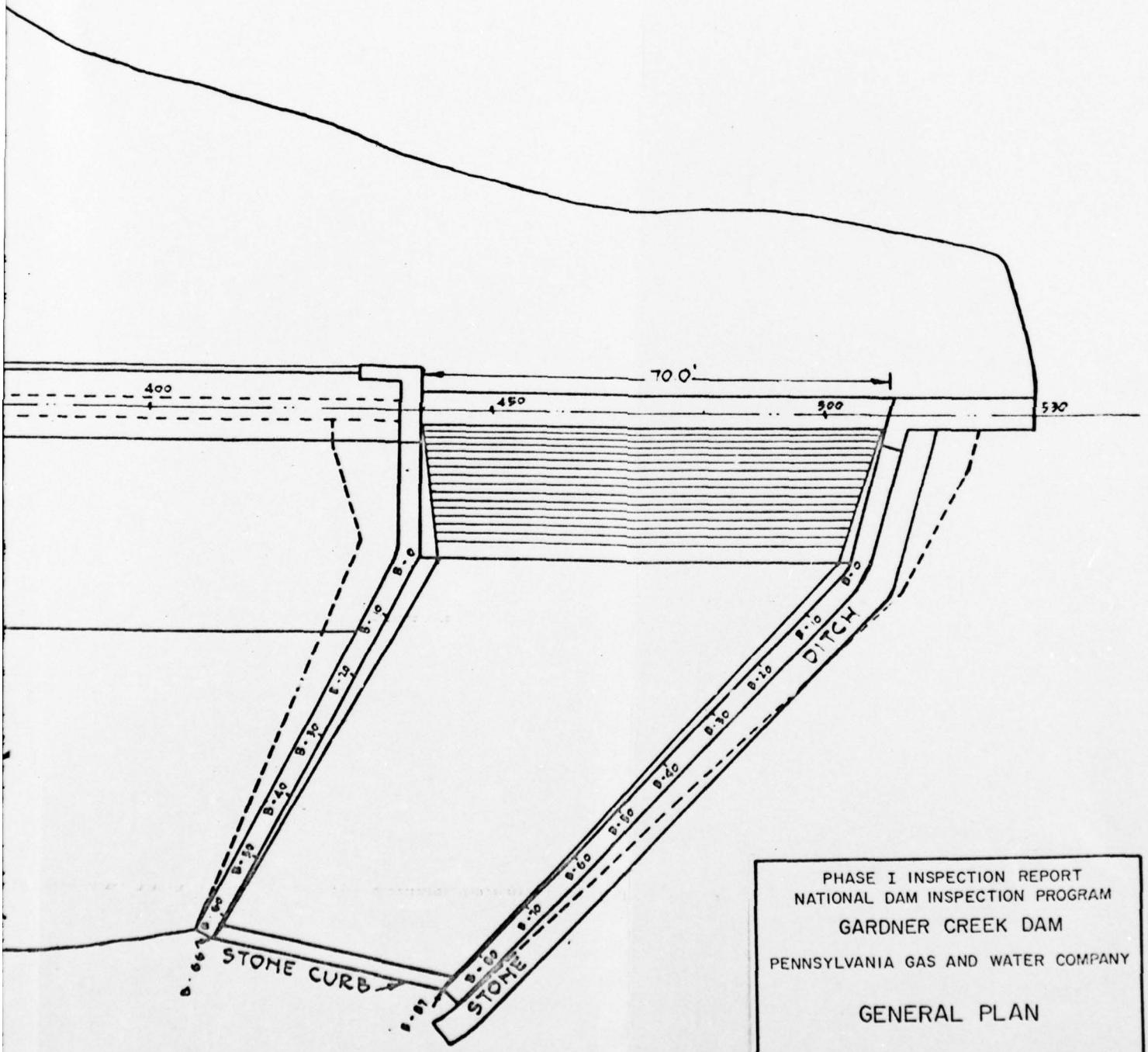

GARDNER CREEK
GARDNER CREEK DAM
Old Boston
Westminster
Mill Creek Res
Reservoir
Mill Creek
Three
Gardner
Warden
Rough
Hollow
Spring
Creek
Mountain
PLAIN
J E N N
E A R C R E E K
0 2000
E: 1 IN. = 2000 FT.
PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
GARDNER CREEK DAM
PENNSYLVANIA GAS AND WATER COMPANY
LOCATION MAP
JUNE 1978
PLATE 1


50
100
150
OLD TOE OF SLOPE
NEW TOE OF SLOPE



PLAN


Flow
300
350
400
10.0'
20' OUTLET PIPES
MASONRY GATE HOUSE
STONE CURB
PLAN



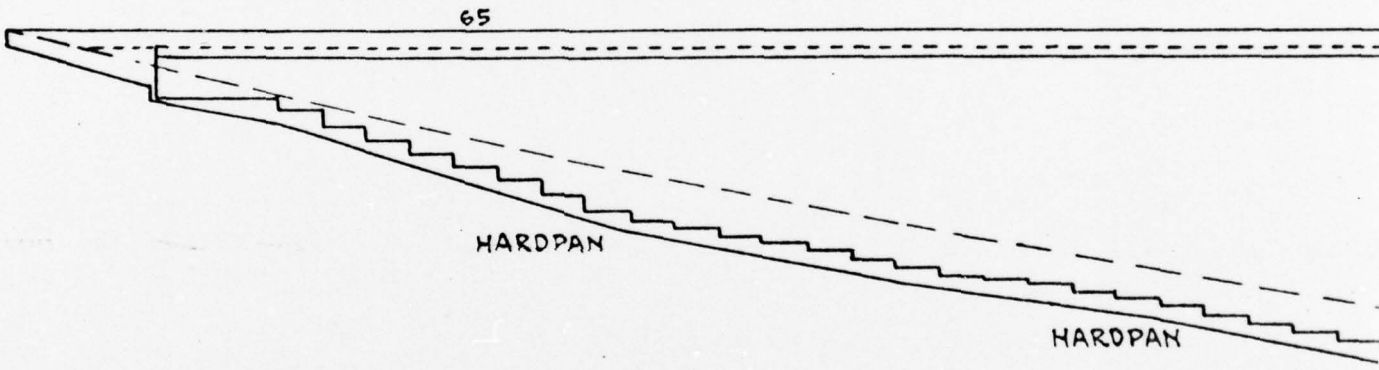
PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

GARDNER CREEK DAM

PENNSYLVANIA GAS AND WATER COMPANY

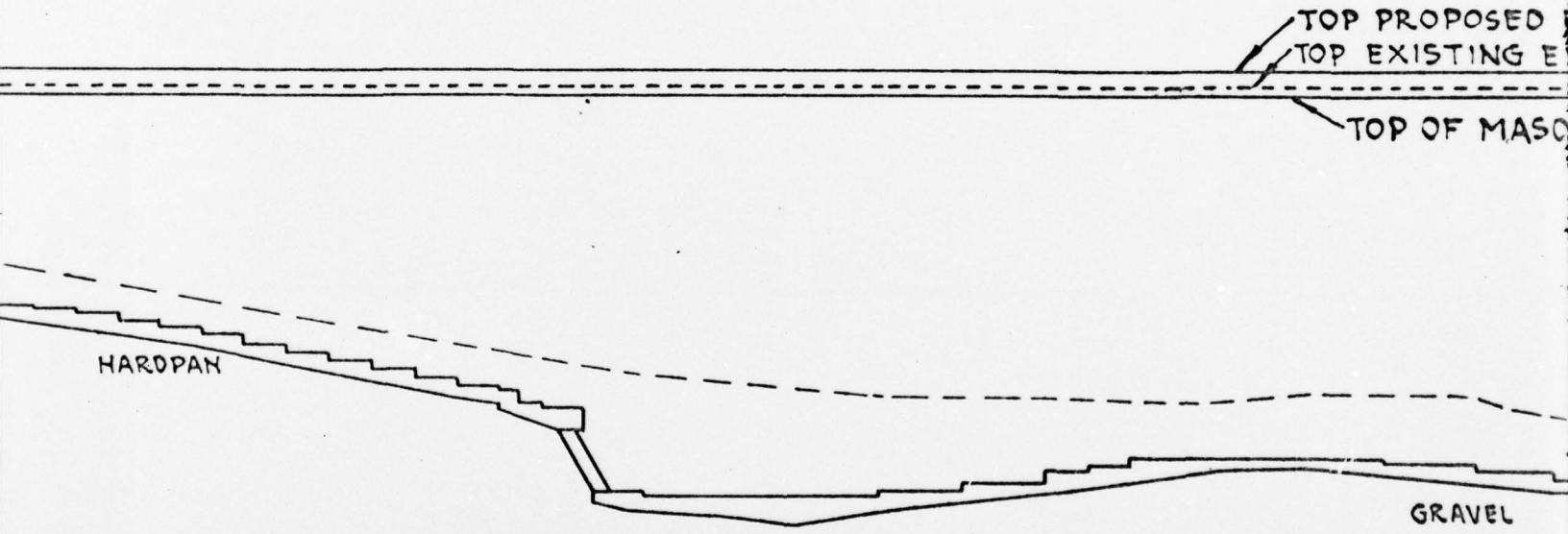
GENERAL PLAN

JUNE 1978 PLATE 2

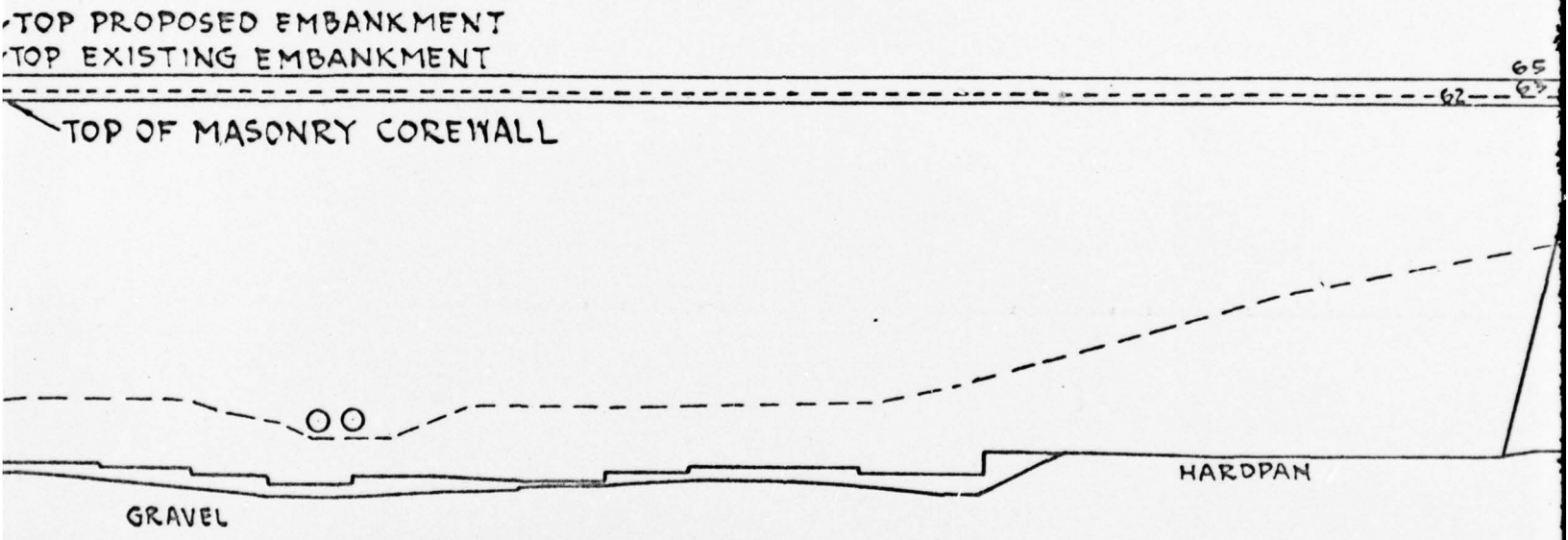


NOTE:

ELEV. 60.0 = TIDAL ELEV. 1075.4



SECTION



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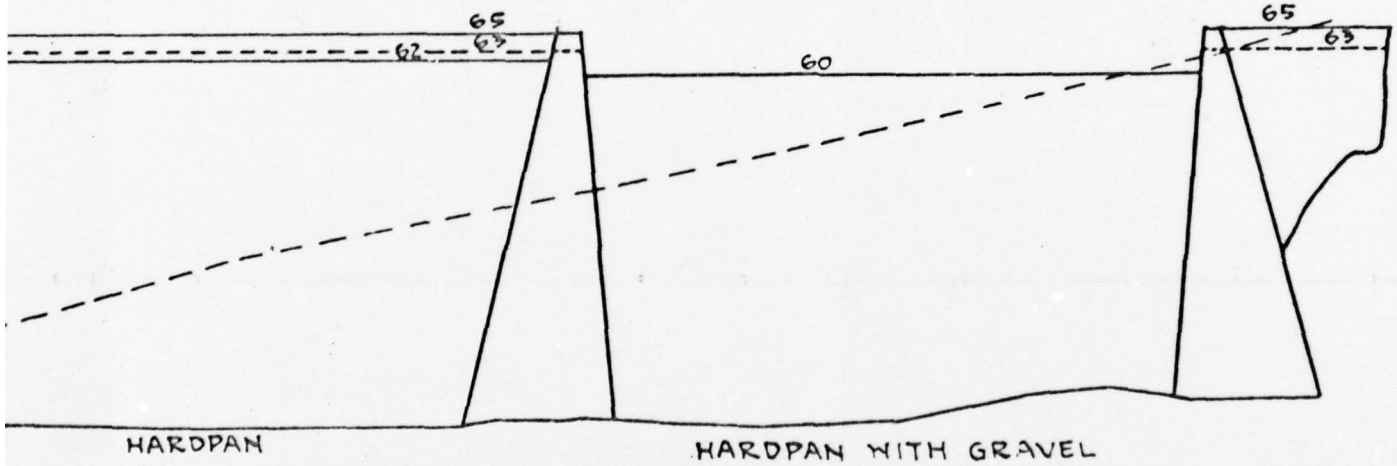


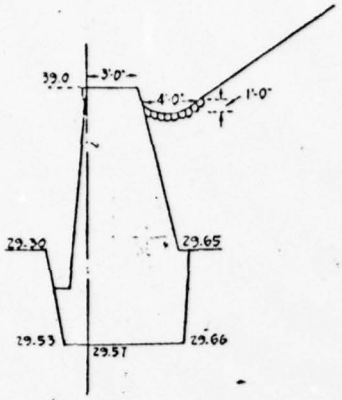
PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

GARDNER CREEK DAM

PENNSYLVANIA GAS AND WATER COMPANY

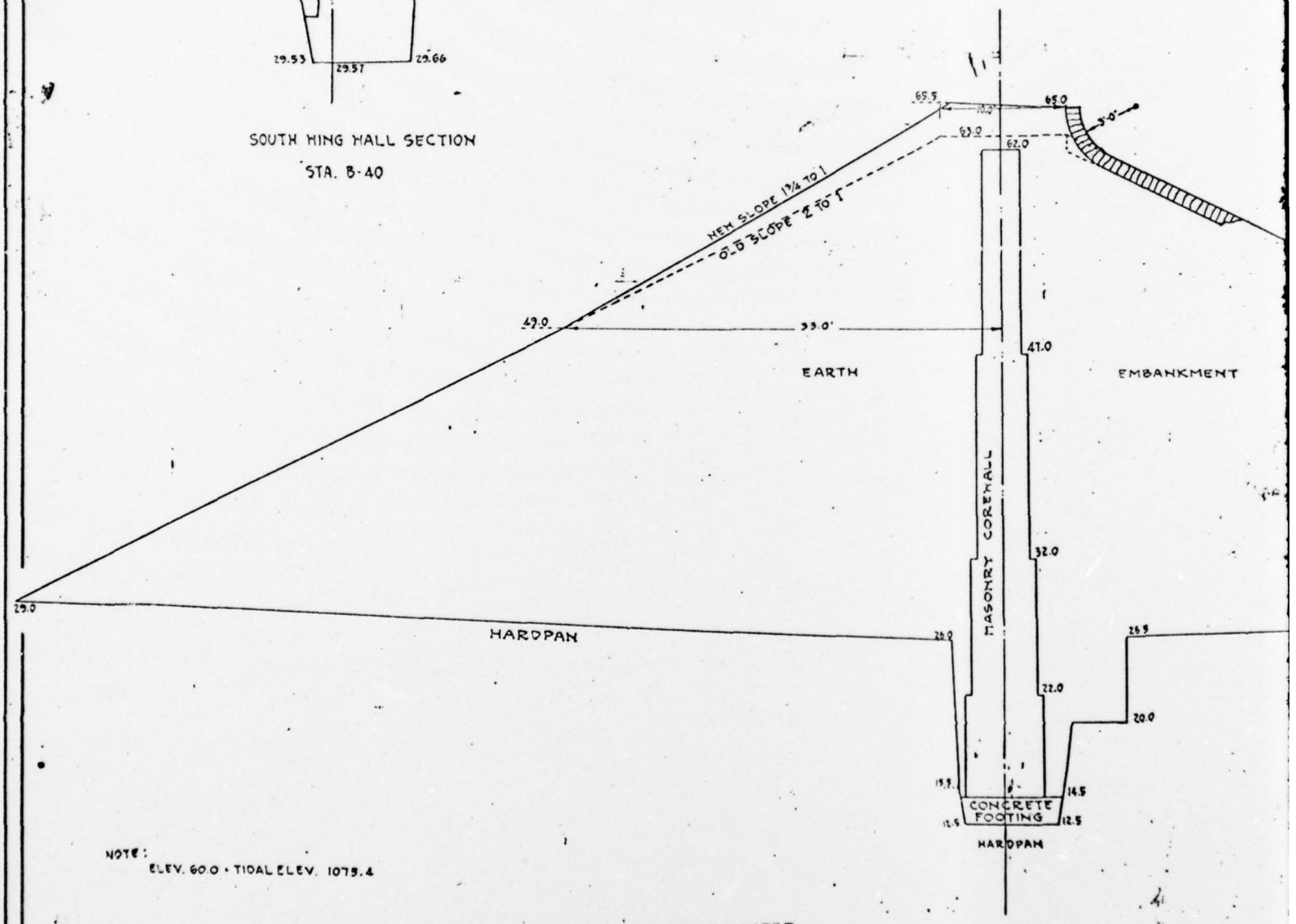
PROFILE ALONG AXIS OF DAM

JUNE 1978 PLATE 3



SOUTH WING WALL SECTION

STA. B-40

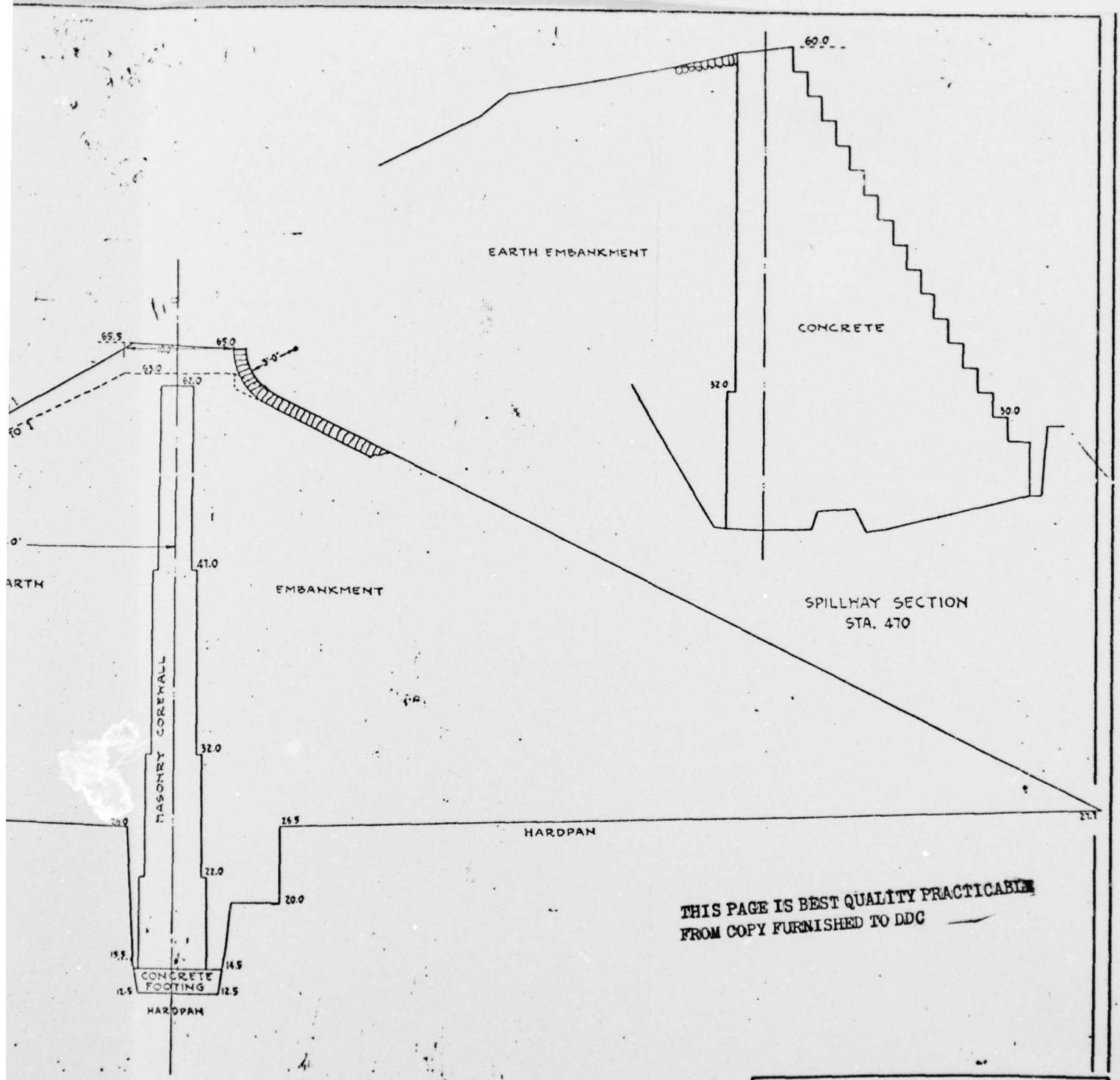


NOTE:
ELEV. 60.0 = TIDAL ELEV. 1079.4

EARTH EMBANKMENT SECTION

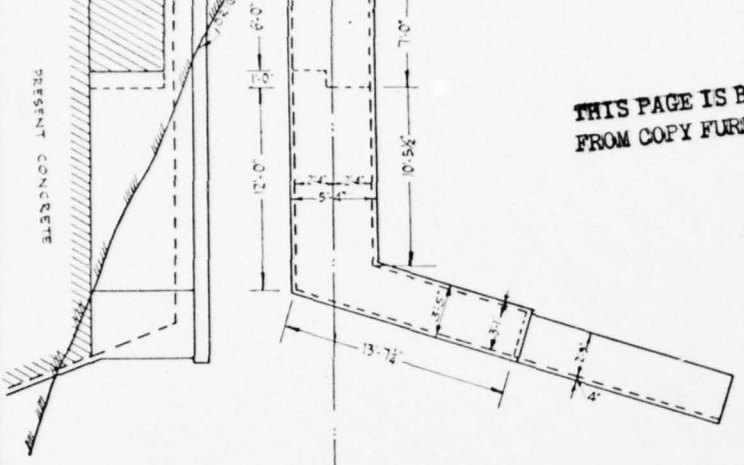
STA. 200

REFER TO ORIGINAL SECTIONS D-806-A & D-806-C

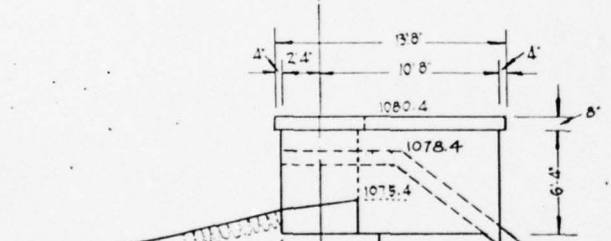


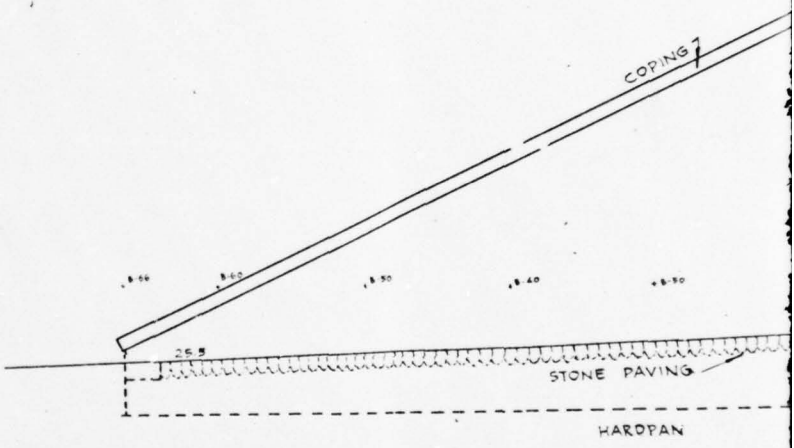
PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
GARDNER CREEK DAM
PENNSYLVANIA GAS AND WATER COMPANY
EMBANKMENT AND
SPILLWAY SECTIONS
JUNE 1978 PLATE 4

SHEET 2

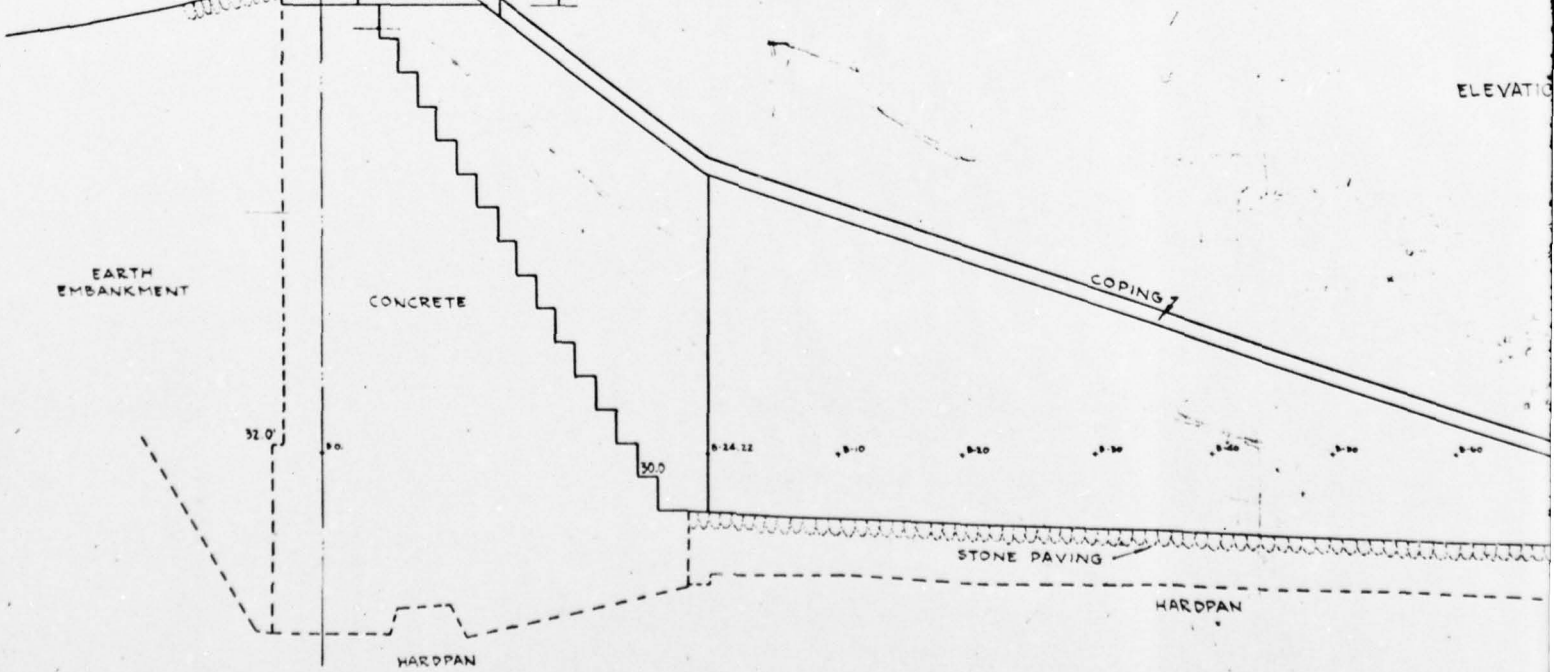


PLAN OF SOUTH WING WALL





ELEVATIO

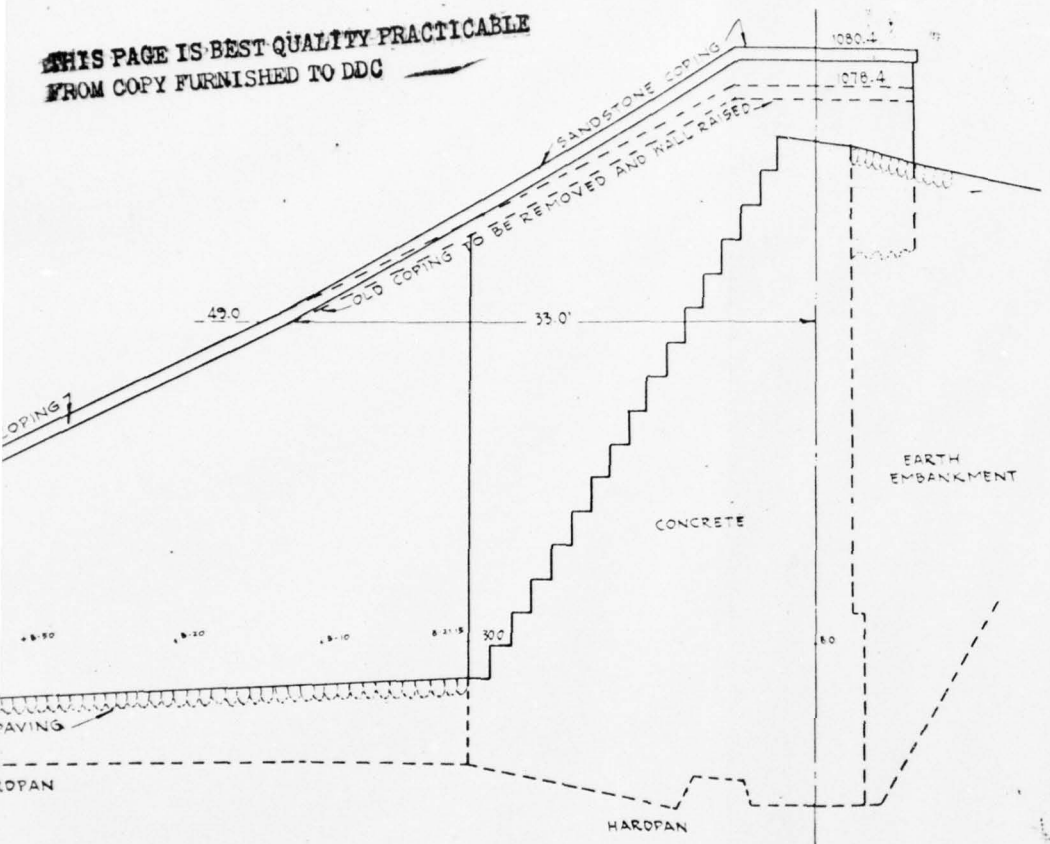


ELEVATION OF SOUTH WING WALL

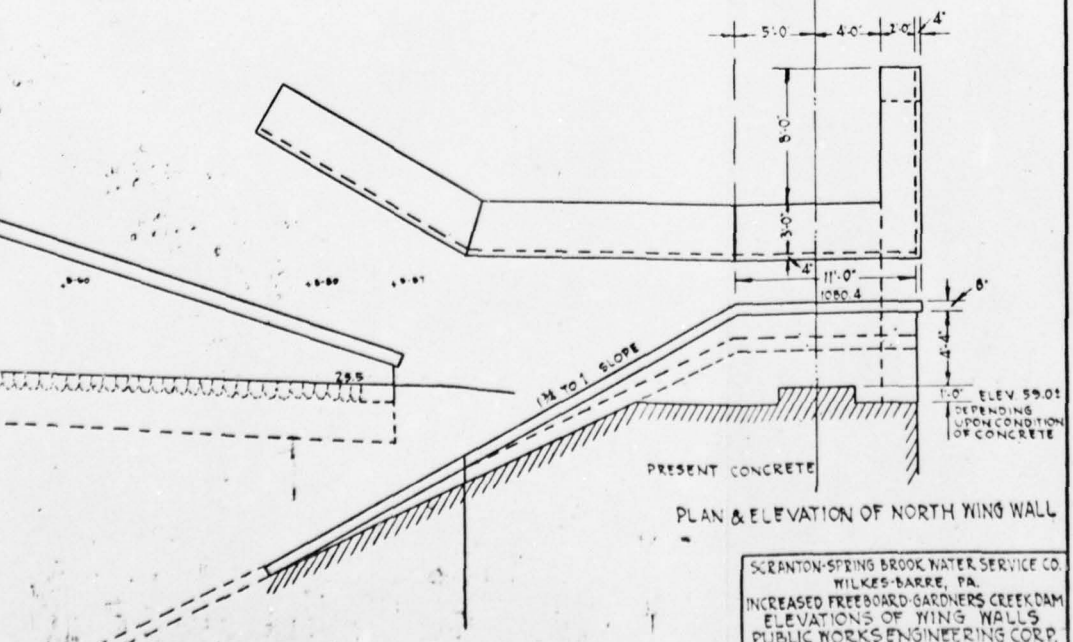
NOTE:
ELEV. 60.0 = TIDAL ELEV. 1075.4

REVISED OCT 8, 1929

REFER TO ORIGINAL SECTIONS D-206-b AND PLAN D-206-b



ELEVATION OF NORTH WING WALL



PLAN & ELEVATION OF NORTH WING WALL

SCRANTON-SPRING BROOK WATER SERVICE CO.
WILKES-BARRE, PA.
INCREASED FREEBOARD GARDNERS CREEK DAM
ELEVATIONS OF WING WALLS
PUBLIC WORKS ENGINEERING CORP.
30 N. FRANKLIN ST., WILKES-BARRE, PA.

DRAWN BY D.J.	DATE 7-25-29	D-206-P
TRACED BY D.J.	SCALE 1"=5 FT.	
CHECKED BY	APPROVED BY	

SHEET 4

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

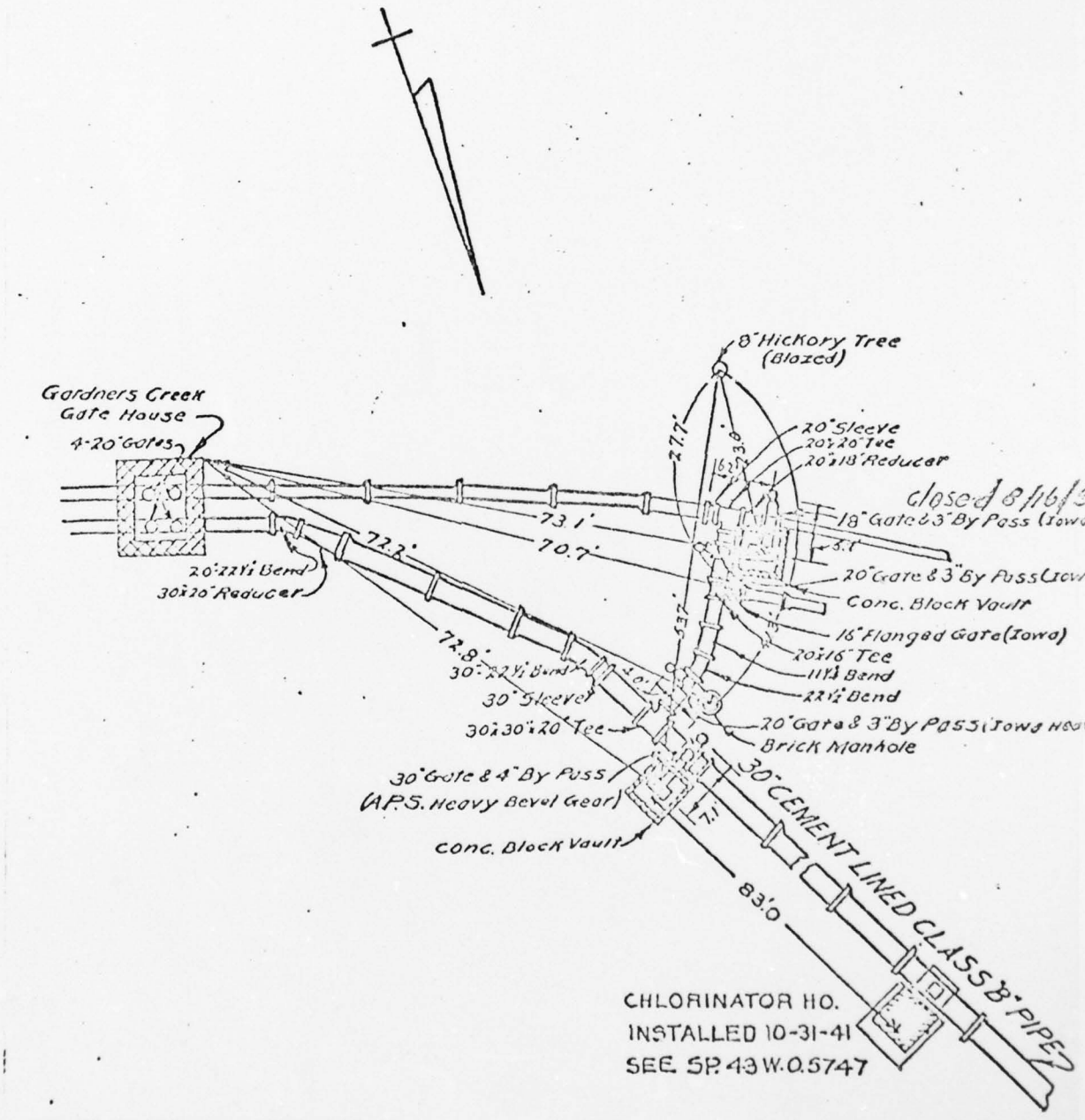
GARDNER CREEK DAM

PENNSYLVANIA GAS AND WATER COMPANY

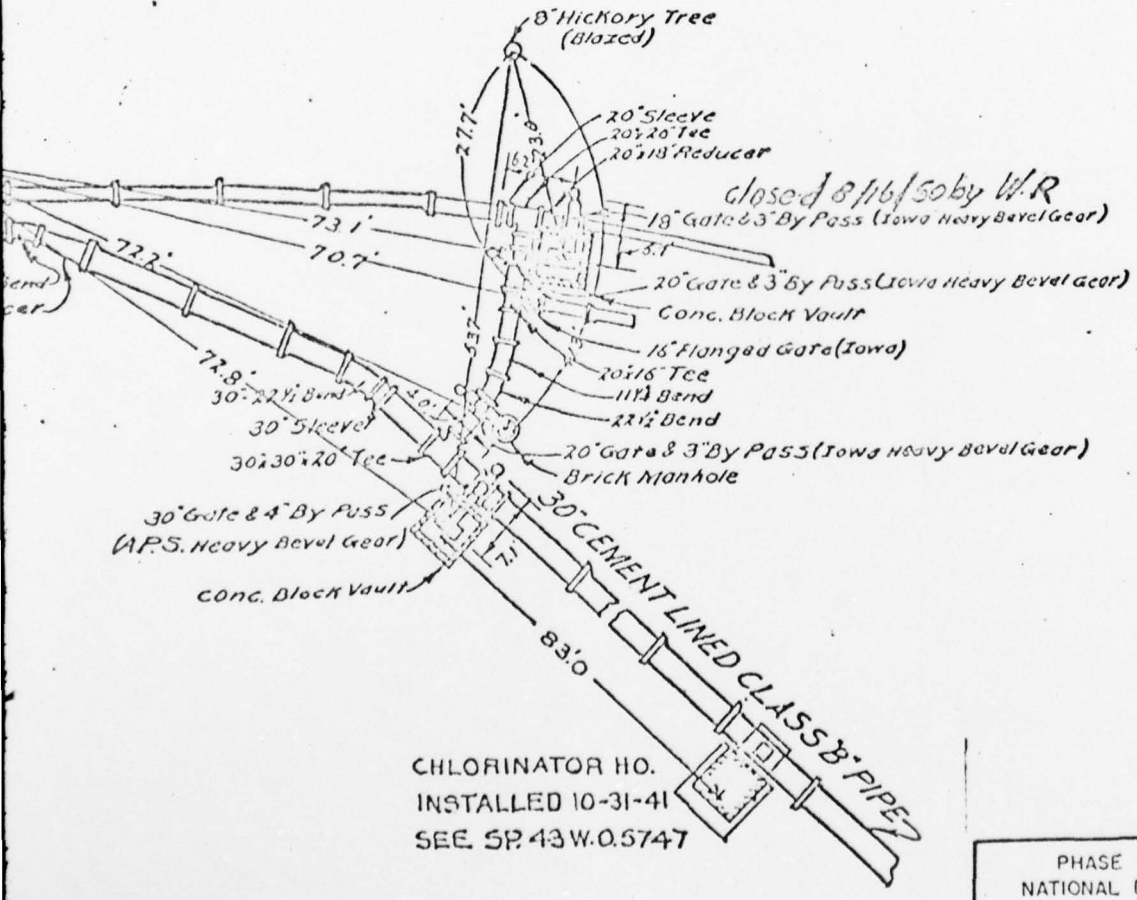
SPILLWAY WALL ELEVATIONS

JUNE 1978 PLATE 5

2



PUBLIC WORKS ENGINEERING CORP'N
PENNSYLVANIA DISTRICT OFFICE
WILKES-BARRE, PA.



PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

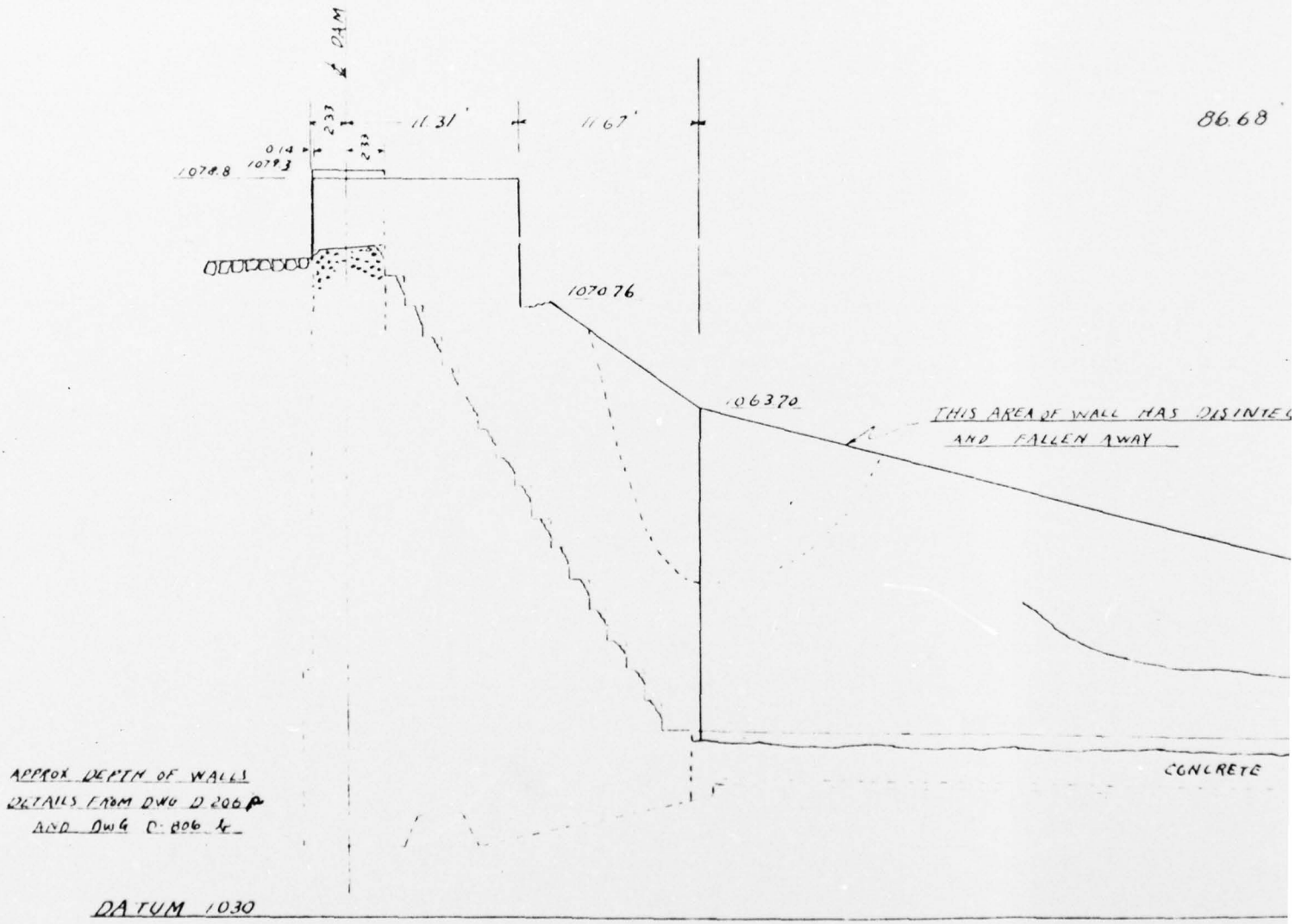
GARDNER CREEK DAM

PENNSYLVANIA GAS AND WATER COMPANY

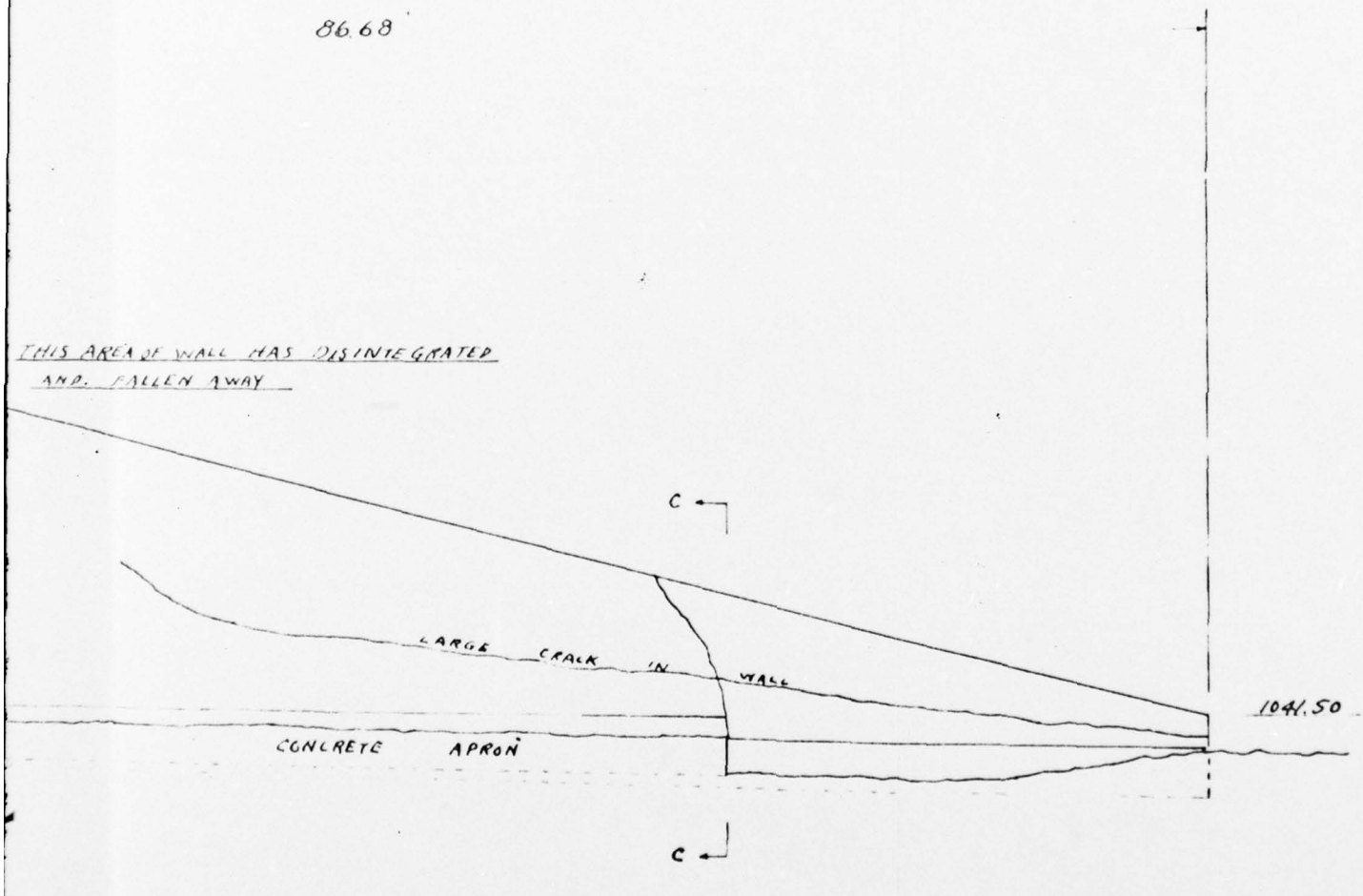
PLAN OF OUTLET WORKS

JUNE 1978 PLATE 6

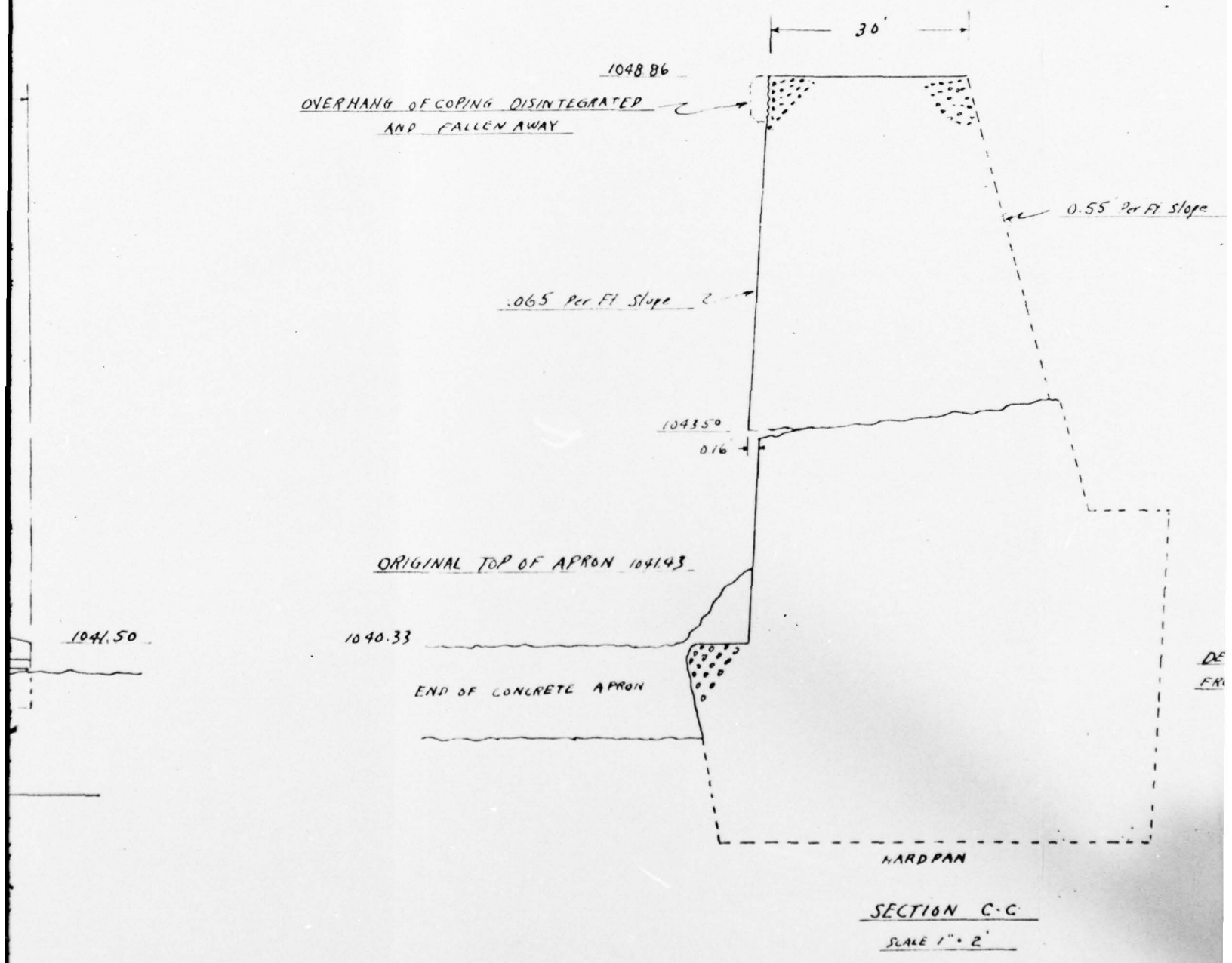
2



ELEVATION OF SOUT
SECTION B-B
SCALE 1" = 10'

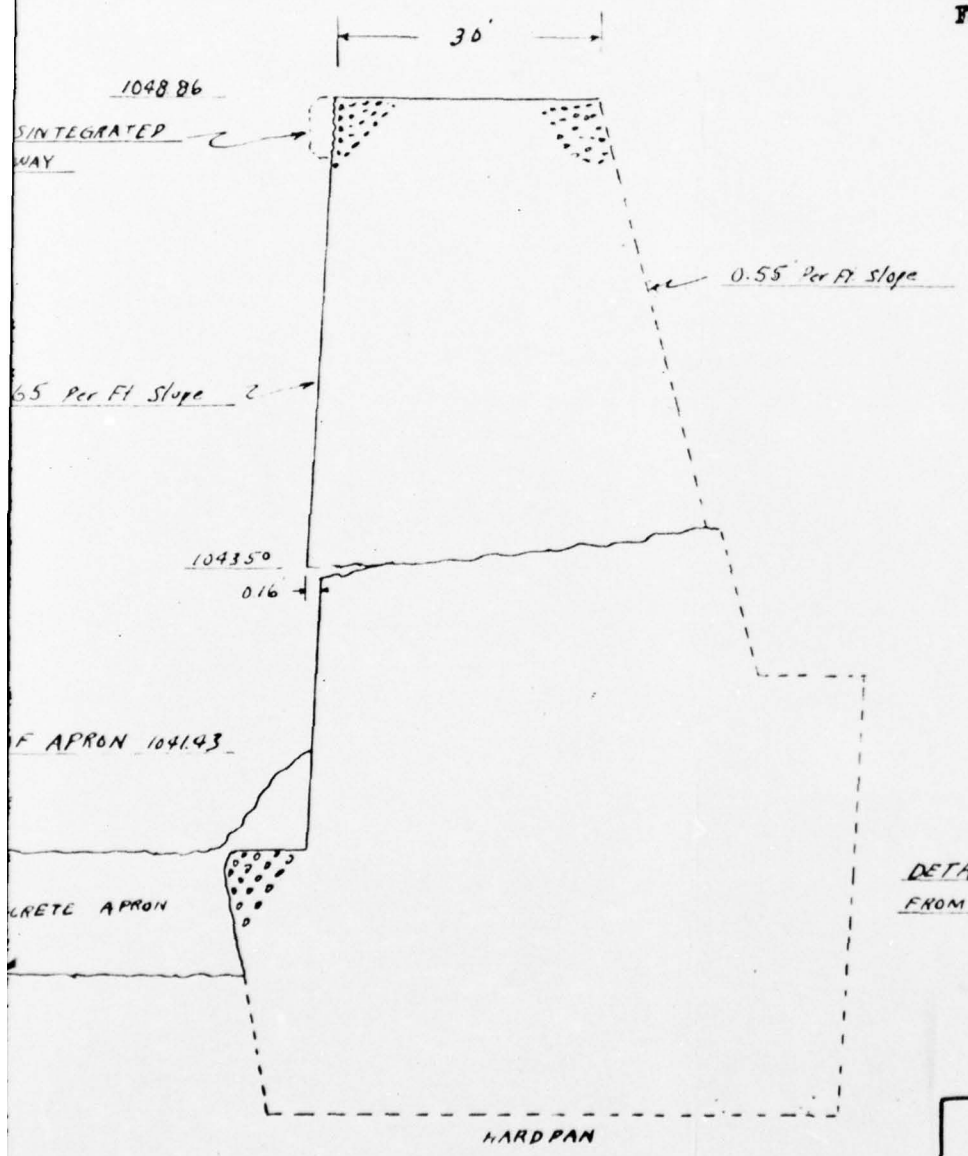


ELEVATION OF SOUTH WING WALL
SECTION B-B
SCALE 1" = 10'



SECTION C-C

SCALE 1" = 2'



SECTION C-C

SCALE 1" = 2'

DETAILS OF WING WALL
FROM DWG. D-206 & AND D-806-4

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
GARDNER CREEK DAM
PENNSYLVANIA GAS AND WATER COMPANY
CONDITION OF
LEFT SPILLWAY WALL - 1950
JUNE 1978 PLATE 7

SUSQUEHANNA RIVER BASIN

GARDNER CREEK, LUZERNE COUNTY

PENNSYLVANIA

GARDNER CREEK DAM

NDS ID No. PA-00575
DER ID No. 40-1

PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JUNE 1978

APPENDIX A

CHECKLIST - ENGINEERING DATA

CHECKLIST

ENGINEERING DATA

DESIGN, CONSTRUCTION, AND OPERATION
PHASE I

NAME OF DAM: Gardner Creek Dam

NDS ID NO.: PA-00575 DER ID NO.: 40-1

Sheet 1 of 4

ITEM	REMARKS
AS-BUILT DRAWINGS	Construction drawings for 1930 modifications.
REGIONAL VICINITY MAP	Project is shown on Pittston, Pennsylvania. Quadrangle Sheet N4115-W7545/7.5, 1947, photo revised 1969.
CONSTRUCTION HISTORY	Constructed 1898-1902 by Spring Brook Water Supply Company. Modified 1930.
TYPICAL SECTIONS OF DAM	Available.
OUTLETS: Plan Details Constraints Discharge Ratings	Plan available. Details available by description. No discharge ratings.

ENGINEERING DATA

ITEM	REMARKS
RAINFALL/RESERVOIR RECORDS	None.
DESIGN REPORTS	Design report dated 1901 by Chief Engineer for project. Permit application report for 1930 modification.
GEOLOGY REPORTS	General geologic description in 1901 design report and 1914 report.
DESIGN COMPUTATIONS: Hydrology and Hydraulics Dam Stability Seepage Studies	1914 hydraulic and stability analyses for spillway.
MATERIALS INVESTIGATIONS: Boring Records Laboratory Field	Compressive strength of stone used for core wall.
POSTCONSTRUCTION SURVEYS OF DAM	1950: Drawings showing extent of deterioration of spillway and spillway walls.

ENGINEERING DATA

ITEM	REMARKS
BORROW SOURCES	Upstream earthfill borrowed from reservoir area. Stone quarried from 2000 feet downstream.
MONITORING SYSTEMS	None.
MODIFICATIONS	1930: Repaired surfaces of spillway walls and raised embankment 2.0 feet.
HIGH POOL RECORDS	None.
POSTCONSTRUCTION ENGINEERING STUDIES AND REPORTS	1914: Evaluation of stability and hydraulics of spillway. 1953: Preliminary design for increasing spillway capacity.
PRIOR ACCIDENTS OR FAILURE OF DAM: Description Reports	None.

ENGINEERING DATA

ITEM	REMARKS
MAINTENANCE AND OPERATION RECORDS	No detailed operation records.
SPILLWAY: Plan Sections Details	Plan and sections available.
OPERATING EQUIPMENT: Plans Details	Plan and description available.
PREVIOUS INSPECTIONS Dates Deficiencies (Continued on Sheet A-5)	1919: Wet areas at toe; spillway concrete deteriorated; no sod on downstream slope; erosion of downstream slope. 1920: Swampy area near gatehouse; water flowing from borrow pit at right end of dam; concrete deteriorated; erosion of downstream slope; brush on downstream slope. 1921: Same as 1920. 1922: Same as 1920. 1923: Same as 1920. 1925: Same as 1920.

ENGINEERING DATA

ITEM	REMARKS
PREVIOUS INSPECTIONS (Continued from Sheet A-4)	1926: Same as 1920. 1927: Same as 1920. 1929: Same as 1920 except brush cut on downstream surface. 1930: Embankment was regraded; small stream emerging below spillway; pool below gatehouse; concrete badly deteriorated. 1932: Same as 1930. 1933: Seepage at gatehouse and 75 feet right of gatehouse; seepage from hillside at right end dam; concrete disintegrated. 1941: Riprap displaced at spillway right abutment; heavy brush on downstream slope; concrete badly disintegrated; seepage at gatehouse and hillside at right end of dam. 1943: Same as 1941. 1965: Concrete disintegrated; no other deficiencies noted.

CHECKLIST

ENGINEERING DATA

HYDROLOGY AND HYDRAULICS

NAME OF DAM: Gardner Creek Dam NDS ID NO.: PA-00575 DER ID NO.: 40-1

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): Elevation 1075.4

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): Elevation 1080.6

ELEVATION MAXIMUM DESIGN POOL: Elevation 1080.6.

ELEVATION TOP DAM: Elevation 1080.6

SPILLWAY CREST:
- a. Elevation 1075.4
- b. Type Broad crested weir.
- c. Width 4.0'
- d. Length 70.3'
- e. Location Spillover Left abutment of dam.
- f. Number and Type of Gates None.

OUTLET WORKS:
- a. Type Two 20-inch CIP
- b. Location Near center of dam.
- c. Entrance Inverts Elevation 1032.0
- d. Exit Inverts Elevation 1031.0
- e. Emergency Draindown Facilities One 16-inch CIP

HYDROMETEOROLOGICAL GAGES:
- a. Type None
- b. Location None
- c. Records None

MAXIMUM NONDAMAGING DISCHARGE: Unknown

SUSQUEHANNA RIVER BASIN

GARDNER CREEK, LUZERNE COUNTY

PENNSYLVANIA

GARDNER CREEK DAM

NDS ID No. PA-00575
DER ID No. 40-1

PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JUNE 1978

APPENDIX B

CHECKLIST - VISUAL INSPECTION

CHECKLIST

VISUAL INSPECTION

PHASE I

Name of Dam: Gardner Creek Dam County: Luzerne State: Pennsylvania

NDS ID No.: PA-00575 DER ID No.: 40-1

Type of Dam: Earthfill with Masonry Core Wall Hazard Category: High

Date(s) Inspection: 22 May 1978 Weather: Clear Temperature: 72°

Pool Elevation at Time of Inspection: 1075.5 msl/Tailwater at Time of Inspection: 1040.0 msl

Inspection Personnel:

D. Wilson (GFCC)	D. Ebersole (GFCC)	C. Kresge (PG&W)
W. Seip (GFCC)	D. Kaufmam (PG&W)	J. Chernesky (DER)
D. Wolf (GFCC)	J. Skoritowski (PG&W)	J. Labuz (DER)

D. Wilson (GFCC) Recorder

EMBANKMENT

Sheet 1 of 2

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None.	
SLOUGHING OR EROSION: Embankment Slopes Abutment Slopes	None.	
CREST ALIGNMENT: Vertical Horizontal	Horizontal: no irregularities. Vertical: average top elevation = 1080.6; low area at spillway = 1079.2; high area at right abutment = 1081.3.	
RIPRAP FAILURES	Riprap missing from spillway to 30 feet right of spillway; otherwise intact.	Downstream surface has weeds and very small shrubs; slope was brushed this year; not normally mowed. One hole by burrowing animal - active.

EMBANKMENT

Sheet 2 of 2

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT WITH: Abutment Spillway Other Features	No deficiencies noted.	
ANY NOTICEABLE SEEPAGE	1. Wet area at gatehouse; some standing water. 2. Flow from right hillside.	1. No discernible flow. 2. Originates well above dam; causing no damage. Caretaker said possible waterline leak is source.
STAFF GAGE AND RECORDER	None.	
DRAINS	None.	
UPSTREAM SURFACE	Some light brush at water level.	

OUTLET WORKS

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Not applicable.	
INTAKE STRUCTURE	Pipe intakes not accessible.	
OUTLET STRUCTURE	Gatehouse at toe of embankment.	Slight standing water on floor of gatehouse.
OUTLET CHANNEL	Small spring at bottom of channel about 10 feet beyond blowoff outlet. Clear, slight flow.	Source could not be determined.
EMERGENCY GATE	16-inch gate valve on blowoff line.	Valve located underground. Opened easily.

UNGATED SPILLWAY

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Concrete on crest and downstream face disintegrated to depths of 6 inches.	Coarse aggregate exposed. Flow over crest is uneven.
APPROACH CHANNEL	Light brush in approach channel.	Not an operating constraint.
DISCHARGE CHANNEL	Concrete apron not visible.	Assume covered with rubble and debris.
LEFT WALL	1. Severe disintegration over 80% exposed face. 2. Crack about 70 feet long.	1. Estimated maximum depth about 2 feet. Could not determine average value. 2. Average displacement about 0.35 feet.
RIGHT WALL	1. Very severe scaling over about 30% exposed face. 2. Vertical crack near downstream end.	1. Average depth about 1 inch. 2. Weathered; no apparent movement.

INSTRUMENTATION

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None.	
OBSERVATION WELLS	None.	
WEIRS	None.	
PIEZOMETERS	None.	
OTHER	None.	

RESERVOIR AND WATERSHED

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	No evidence of rock slides, creep, or land slides.	
SEDIMENTATION	No major problem reported by Owner.	
WATERSHED DESCRIPTION	Completely owned and controlled by PG&W; no development; hardwood cover; hilly.	

DOWNSTREAM CHANNEL

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION: Obstructions Debris Other	1. Turnpike underpass located 2000 feet downstream. Embankment about 35 feet high. 2. R.R. underpass 60' downstream from Turnpike underpass (25' high)	1. Culvert is horseshoe; 18.6' wide x 13.0' high with 9.0' radius at top; 330' long. 2. Horseshoe culvert 9.8' wide x 12' high with 5.0' radius at top; 100' long.
SLOPES	No undue erosion.	
APPROXIMATE NUMBER OF HOMES AND POPULATION	Some low-lying houses about 0.5 mile downstream; community of Laflin about 3 miles downstream.	

SUSQUEHANNA RIVER BASIN

GARDNER CREEK, LUZERNE COUNTY

PENNSYLVANIA

GARDNER CREEK DAM

NDS ID No. PA-00575
DER ID No. 40-1

PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JUNE 1978

APPENDIX C

HYDROLOGY AND HYDRAULICS

CLASSIFICATION

HIGH HAZARD, SINCE POPULATION DOWNSTREAM IS 51

INTERMEDIATE SIZE, SINCE HEIGHT = 43 FEET AND CAPACITY = 74+ MILLION GALLONS
REFERENCE: "RECOMMENDED GUIDELINES FOR SAFETY INSPECTION OF DAMS," p. D-3.

SPILLWAY DESIGN FLOOD (SDF)

THE SDF SHOULD BE THE PMF (FROM p. D-12 OF "REC GUIDELINES...")

HYDROLOGY AND HYDRAULICS ANALYSIS

REFERENCE: PHASE I PROCEDURE PACKAGE

II. A. 2. PMF INFLOW HYDROGRAPH NOT AVAILABLE

a. PRORATE PMF AT GARDNERS CREEK, D.A. = 3.7 SQ. MI., WITH PMF PEAK OF 9,700 CFS AT FALLS BROOK, D.A. = 4.14 SQ. MI.

from contact with Michael Kanowitz

$$\text{Gardner Creek} = 9700 \text{ cfs} \left(\frac{3.7}{4.14}\right)^{0.8}$$

$$= 9700 \times 0.914 = 8870 \text{ cfs}$$

$\therefore X = 8870$ CFS = PMF PEAK INFLOW FOR GARDNERS CREEK DAM

Neglect $6{,}000{,}000 \frac{\text{gal}}{\text{day}} = 9.3 \text{ cfs}$ controlled inflow from Watres Dam
EFFECT OF UPSTREAM RESERVOIR(S)

NEGLECT EFFECT OF HARLAN POND (D.A. LESS THAN 5% OF TOTAL D.A.)

B. ABILITY OF SPILLWAY TO PASS PMF

1. CAPACITY OF SPILLWAY

AVAILABLE HEAD, H, ON SPILLWAY 1079.2 − 1075.4 = 3.8' GFCC Survey data
LENGTH OF SPILLWAY CREST = 70.0'
RESERVOIR AREA AT SPILLWAY CREST = 15.1 ACRES* (WSC of PA, 1974)

* PLANIMETERED VALUE. AGREES WITH 1953 WIGGIN ESTIMATE.

SP 11660A

Estimate Spillway Capacity

use $Q = CLH^{3/2}$

From 12/53 Wiggin Report, Estimated Capacity = 2,620 cfs

$$2620 = C(70.0)(5.2)^{3/2}$$

$$C = 3.16$$

∴ existing conditions

$$Q = 3.16(70.0)(3.8)^{3/2} = 1638 \text{ cfs, say } \underline{1640 \text{ cfs}}$$

3. The PMF peak flow is greater than spillway capacity (8870 > 1640)

b. Routing of the PMF is not available

(1) The spillway will pass $\left(\frac{1640}{8870} \times 100\right) = 18.5\%$ of the PMF Peak

(3.) Enclosure 3 Method to estimate storage effect of reservoir

(a.) Triangular Shape for PMF hydrograph

(b.) From Michael Kanowitz (NAB) - adjust the PMF hydrograph to 24" of runoff.

$$3.7 \text{ Mi}^2 \times \frac{640 \text{ Acre}}{\text{Mi}^2} \times 2 \text{ ft} = 4736 \text{ Acre-Ft}$$

$$4736 = \frac{1}{2} \times 8870 \frac{\text{ft}^3}{\text{sec}} \times \frac{3600 \text{ sec}}{\text{Hr}} \times \frac{1 \text{ Acre}}{43560 \text{ ft}^2} \times b \text{ hrs}$$

$$b = 12.9 \text{ hr}$$

$$\Delta AOC = (1-P)\Delta AOB = (1-0.185)(4736) = 3860 \text{ Acre-Ft required storage}$$

(c.) Estimate Incremental Storage Available

Normal Pool = Spillway Crest = 1075.4 ft. = 15.1 acres

Max Pool = Top of Dam = 1079.2 ft.

Assume that the reservoir can be modeled by using a right circular cone with side slopes of 2H on 1V

$\Delta V = 1079.2 - 1075.4 = 3.8'$ $\Delta H = 2 \cdot 3.8 = 7.6$

$$A_1 = 15.1 \text{ Acres} = \frac{\pi r_1^2}{43560}$$

$$r_1 = 458'$$

$$r_2 = 458 + 7.6 = 465.6$$

$$A_2 = \pi r_2^2 \cdot (1/43560) = 15.6 \text{ Acres}$$

Surcharge Storage = $3.8\left(\frac{15.1+15.6}{2}\right)$ = 58.3 Acre-Ft.

required 3860 > 58.3 avail.

C. Procedure For Determination of Adequate/Inadequate Spillway

2. Storage Required is greater than storage available

a. ETL 1110-2- states three conditions that must exist before the spillway is considered to be seriously inadequate. Check condition "C" = $\frac{1}{2}$ PMF

b. $\frac{1}{2}$ PMF peak flow = $\frac{1}{2}$ 8870 = 4435 cfs.

II. B. Ability of spillway to pass $\frac{1}{2}$ PMF

1. Capacity of spillway = 1640 cfs.

3. $\frac{1}{2}$ PMF Peak is greater than the spillway capacity (4435 > 1640)

b. Routing of $\frac{1}{2}$ PMF is not available

(1) The spillway will pass $(1640/4435) \times 100 = 37\%$ of $\frac{1}{2}$ PMF Peak

(2) Inclosure 3 Method used to estimate storage effect of reservoir

(a) Triangular Shape for $\frac{1}{2}$ PMF Hydrograph

(b) $1-p = 1-(1640/4435) = 0.63$

$\Delta AOB = 3.7 \times 640 = 2368$ Acre-ft. @ 12" of runoff

$\Delta AOC = (1-p)(\Delta AOB) = 0.63 \times 2368 = 1492$ Ac. Ft.

(c) storage available = 58.3 acre-ft. - see above

1492 > 58.3

storage required > storage available

Procedures for determination of adequate/inadequate spillway

2. Storage required is greater than storage available

a. ETL 1110-2-

① There is a high hazard of loss of life from large flows Downstream of Dam

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Gardner Creek Dam FILE NO. 7613.1.1
Hydrology and Hydraulics SHEET NO. 4 OF 6 SHEETS
FOR USCE - Baltimore
COMPUTED BY DAW DATE 6-78 CHECKED BY FFM DATE 7-78

TAILWATER DEPTH ESTIMATE

Q	Depth	
0	0	
1380	6.10	HEC-2 computer run
1638	(6.41)	calculated
2250	7.16	HEC-2 computer run

SP 11860A

② CHECK TAILWATER AT INSTANT BEFORE OVERTOPPING OCCURS

③ THE DAM AND SPILLWAY ARE NOT CAPABLE OF PASSING ½ PMF WITHOUT OVERTOPPING FAILURE

C. TAILWATER AT INSTANT BEFORE OVERTOPPING OCCURS

SPILLWAY CAPACITY DISCHARGE = 1638 CFS; FROM HEC-2 COMPUTER RUN

TAILWATER DEPTH @ Q = 1638 CFS IS 6.4 FEET

TOP OF DAM ELEVATION	=	1079.2'
HEIGHT OF DAM	=	43'
BOTTOM OF DAM ELEV.	=	1,037.4'
TAILWATER DEPTH	=	6.4'
TAILWATER ELEVATION	=	1043.8
TOP OF DAM ELEV - TAILWATER ELEV.	=	35.4'

Percent of PMF which will pass the spillway

$$\% = \frac{\text{spillway capacity} + \frac{2S}{T}}{\text{PMF Peak}} \times 100$$

$$\% = \frac{1640 + \left(\frac{3 \cdot 58.3 \cdot 43560}{3600 \cdot 12.9}\right)}{8870} \times 100 = 19.7\%$$

∴ the spillway will pass $0.197 \times 8870 = 1747$ cfs.

Determine Spillway Capacity if the Embankment is restored to the design level – Elevation 1080.6

$H = 1080.6 - 1075.4 = 5.2'$

(see p 1) $L = 70'$

$C = 3.16$

$W = 8'$

$Q = 3.16 \times 70 \times (5.2)^{3/2} = \underline{2620 \text{ cfs}}$

Estimate Surcharge Storage. (see page 2)

$\Delta V = 5.2'$, $\Delta H = 2(5.2) = 10.4'$

$A_1 = 15.1 \text{ Acres} = \frac{\pi}{43560} \times r_1^2$

$r_1 = 457.57$

$r_2 = r_1 + 10.4 = 467.97$

$A_2 = \frac{\pi}{43560} \times r_2 = 15.8 \text{ Acres}$

surcharge storage $= 5.2 \times \left(\frac{A_1 + A_2}{2}\right) = \underline{80.3 \text{ Acre-Ft.}}$

Estimate % PMF which the Dam can safely pass

$$\% = \frac{Q_{\text{spillway}} + \frac{2S}{T}}{Q_{\text{PMF Peak}}} \times 100$$

$$= \frac{2620 + \frac{2 \times 80.3 \times 43560}{3600 \times 12.9}}{8870} \times 100$$

$$= \underline{31.2\%}$$

$Q_{\max \text{ inflow}} = 0.312 \times 8870 \cong \underline{2770 \text{ cfs}}$ for a storm of the same duration (12.9 hrs) as the PMF

SUSQUEHANNA RIVER BASIN

GARDNER CREEK, LUZERNE COUNTY

PENNSYLVANIA

GARDNER CREEK DAM

NDS ID No. PA-00575
DER ID No. 40-1

PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JUNE 1978

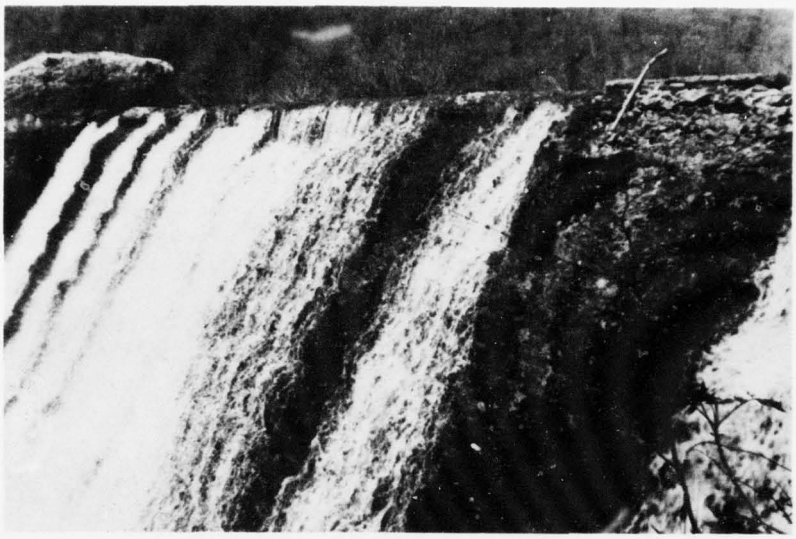
APPENDIX D

PHOTOGRAPHS

GARDNER CREEK DAM

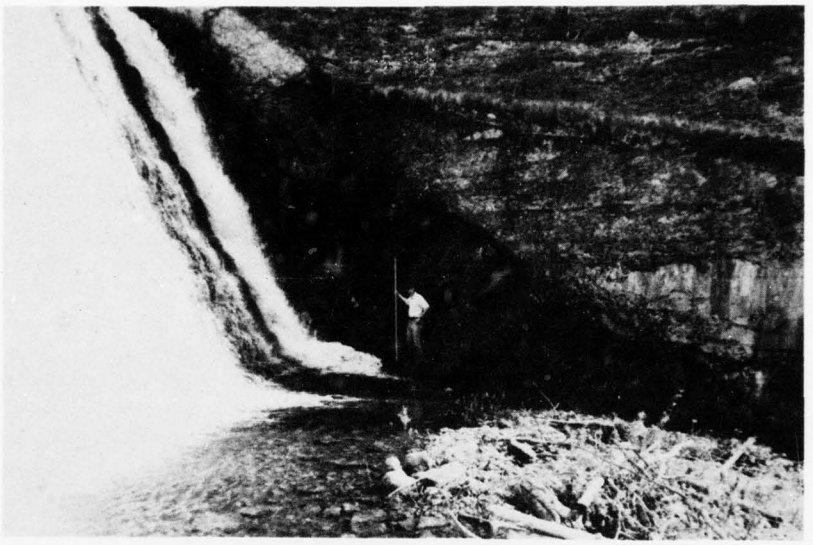
A. Embankment Looking from
Right Abutment

B. Spillway and Embankment Looking from
Left Abutment

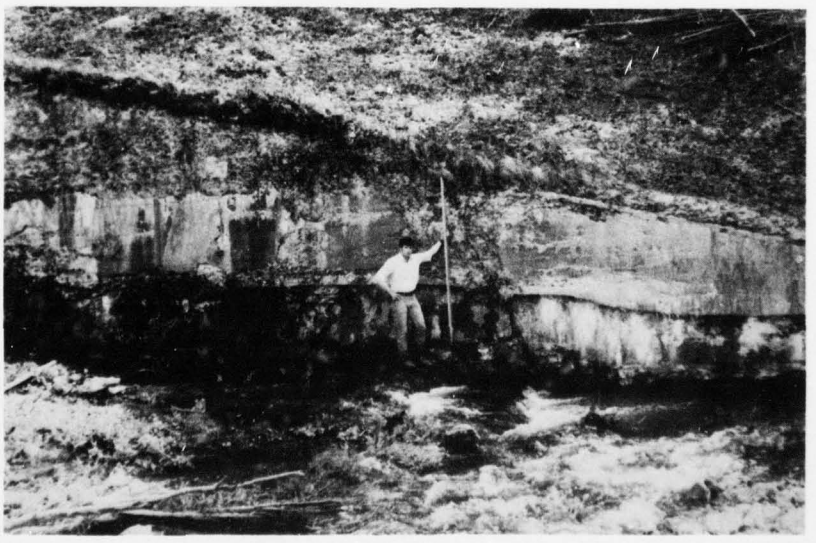


C. Crest and Downstream Face of Spillway

D. Right Spillway Wall

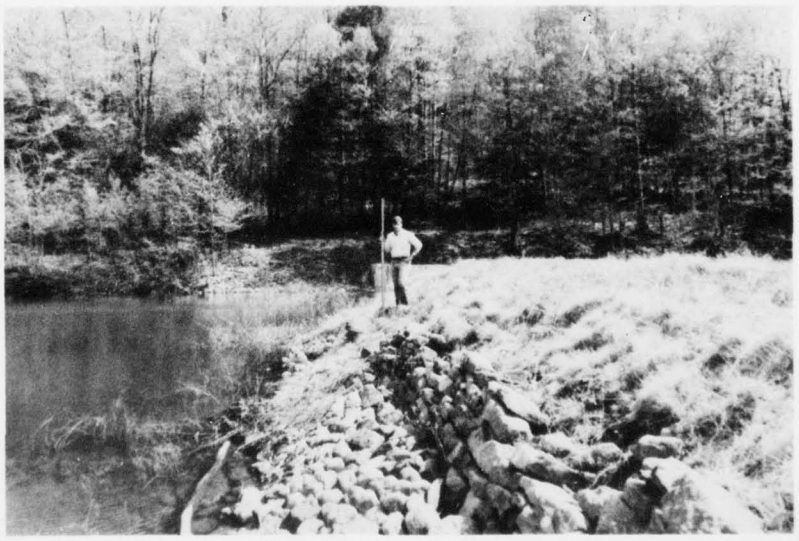


E. Disintegration, Large Crack, and Displacement of Spillway Left Wall

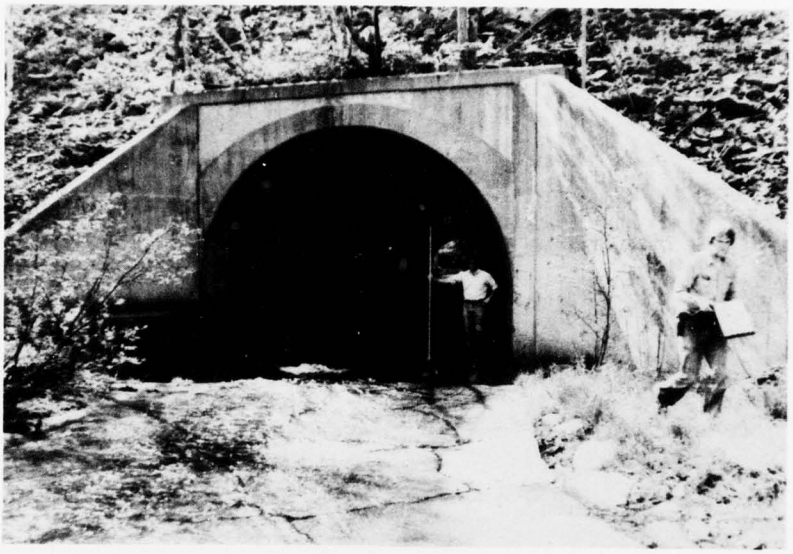


F. Continuation of Above Photo showing Cracking and Displacement of Left Spillway Wall

G. Operation of the 16-Inch Diameter Blowoff



H. Upstream Embankment Surface on Right Side of Spillway showing Missing Riprap Material



I. Outlet Channel Conduit under the Pennsylvania Turnpike, 0.4 Mile Downstream from Dam. Driving through Conduit is Access Route to Dam.

J. Outlet Channel Conduit under Lehigh Valley Railroad located immediately downstream of the Pennsylvania Turnpike Conduit

SUSQUEHANNA RIVER BASIN

GARDNER CREEK, LUZERNE COUNTY

PENNSYLVANIA

GARDNER CREEK DAM

NDS ID No. PA-00575
DER ID No. 40-1

PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JUNE 1978

APPENDIX E

GEOLOGY

GARDNER CREEK DAM

APPENDIX E

GEOLOGY

1. General Geology. The damsite and reservoir are located in Luzerne County. The rock formations exposed in Luzerne County range from the post-Pottsville formations, of Pennsylvania Age, down to the Onondaga formation, of Middle Devonian Age. The Wisconsin terminal moraine crosses the southern part of the County, and the greater part of the County is covered by glacial drift. Extensive deposits of glacial outwash occur along the Susquehanna River and less extensive deposits along the smaller streams.

Nearly all of Luzerne County lies in the Valley and Ridge Province in which nearly all the rocks have been strongly folded. In going from north to south across the County, five major folds are encountered, all of which trend northeast. The first of these is a shallow syncline on the crest of North Mountain, forming the Mehoopany coal basin. The second is the Milton Anticline, which exposes the Portage group in the northwestern part of the County and gradually flattens out toward the northeast. The third and most pronounced is the Lackawanna Syncline, which originates in Lackawanna County to the north, and has preserved the post-Pottsville formations throughout the Wyoming Valley. The maximum depth of this syncline is reached in the vicinity of Wilkes-Barre and Plymouth. The double rim of this syncline is formed by the resistant Pottsville formations and Pocono sandstone, separated by the less resistant Mauch Chunk shale. The fourth fold is the Berwick (Montour) Anticline, which exposes a few feet of the Onondaga formation in the vicinity of Beach Haven. This fold reaches its maximum development farther west and only the eastern portion reaches Luzerne County. The fifth major fold comprises a series of anticlines and synclines forming the Eastern Middle Anthracite Field in the vicinity of Hazleton. The synclinal basins in this region are relatively shallow and there are large areas from which all coalbeds have been eroded.

The general dips of the region vary from 0° to 40°, and the maximum dips are found on the rims and within the synclinal coal basins. The relatively soft post-Pottsville beds in their cores are severely folded and contorted with numerous minor faults. The northern and easternmost parts of the County border the Appalachian Plateau Province and are characterized by horizontal, or nearly horizontal strata. The Catskill continental group of rocks underlies those parts of Luzerne County that are outside of the five major folds.

2. Site Geology. In the area of interest, the Susquehanna River represents the approximate axis of the Lackawanna Syncline. The dam and reservoir are located east of the Susquehanna River in the relatively gentle slope of the left descending limb, looking downstream of the Syncline. Gardner Creek, a tributary of Mill Creek, in the area of the damsite and reservoir, has cut through Pocono sandstone and is now cutting through or flowing upon either decomposed Mauch Chunk shale formations or glacial till. Bedrock is apparently located a good distance below natural ground, since excavations as deep as 16 feet were made in various parts of the foundation without encountering rock.

From construction reports, obtained by Pennsylvania Water Supply Commission engineers in the initial 1914 inspection of the dam, the earthen embankment rests upon a stiff sandy clay containing a high percentage of gravel. The masonry core wall, in the middle of the embankment, is founded upon a hardpan located from 4 to 16 feet below the surface of the natural ground. The spillway, located at the left end of the embankment and at the toe of the steep hillside, is founded upon a hardpan located on an average of about 6 feet below the spillway channel.